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OBSERVATIONS, BOTANICAL AND PHYSIOLOGICAL, ON THE POTATO MURRAIN

By

M. J. BERKELEY

Together with selections from

BERKELEY'S

VEGETABLE PATHOLOGY

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W. BUDDIN
Chairman of the Plant
Pathology Committee

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Biographical Note

Miles Joseph Berkeley was born at Biggin, Oundle, on April 1st, 1803, and died at Sibbertoft, Market Harborough, on July 3rd, 1889. The second son of Charles Berkeley of Biggin Hall, he belonged to a well-known family which traces its descent from Thomas Mowbray, Duke of Norfolk.

Berkeley went to Oundle Grammar School as a day scholar and from there to Rugby and thence, when eighteen, to Christ's College, Cambridge, where he studied for the Mathematical Tripos; he was fifth senior optime in 1825. He had normal tastes for an undergraduate of those days—archery, billiards, dancing and riding. He had, however, taken an interest in natural history since childhood; his close friend, R. T. Lowe, had similar tastes and they spent some of their long vacations together. The teaching of botany in the University was non-existent as Professor T. Martyn had not lectured since 1796 and refused to allow anyone else to lecture on the subject.

With no guidance Berkeley, for some reason, became interested in microscopic organisms and first discovered the alga *Chlorococcum murorum* on the freestone walls of his college. During his undergraduate days he collected algae, mosses and mollusca.

In 1826 he was admitted deacon and curate in the Church of England, being ordained priest in the following year. He was curate at Margate in 1830. From 1833 to 1868 he was rector at Kings Cliffe and then, till his death, at Sibbertoft. He was appointed Rural Dean of Rothwell in 1854.

His first scientific paper appeared in 1826 and was concerned with a new species of the mollusc *Modiola*, and in the next ten years five other papers on molluscs were published. Meanwhile, however, like others of his period he was greatly influenced by R. K. Greville's *Scottish Cryptogamic Flora* which appeared in monthly parts from 1823 to 1828. He sent a collection of algae, fungi and lichens to Greville in 1826 and during the next six years kept up the practice, adding mosses and flowering plants. Greville named the algal genus *Berkleya* after him in 1827.

Berkeley sent a number of drawings of algae to Greville with a

view to their being used as a supplement to the *Flora*, but as this had not been a success it was not revived. Berkeley, therefore, arranged for twenty plates with his own text to be issued as *Gleanings of British Algae* in 1833. This small work has considerable merit but it was immediately overshadowed by the appearance of the *English Flora*.

W. J. Hooker, who was then Professor of Botany at Glasgow, wished for specimens of the rare moss *Phascum crassinervium* which Berkeley had found and Greville asked him to send these direct. This Berkeley did adding other mosses and fungi. In acknowledging the gift Hooker commented on the fungi, saying that all cryptogams had more charms for him than ever because he had undertaken to complete J. E. Smith's *English Flora*, and asked for his assistance with communications. This was the beginning of a long and fruitful friendship with Hooker and afterwards with his son J. D., and, moreover, set Berkeley on the path he was to illumine. In 1832 Hooker asked to see Berkeley's drawings and descriptions of agarics and then offered to leave the writing of this part of the *Flora* to him. The account was finished in eighteen months and Hooker was so satisfied with it that he handed over the whole of the fungus volume to him. The manuscript was finished in October 1835 and published the following year. The work shows no sign of the pressure under which it was written and was of such merit that Berkeley at the age of thirty-three became the recognised British authority on fungi. Henceforth his main interest was in mycology and this interest was fanned by Hooker's constant stimulation. Thus Hooker, after enquiring whether such specimens were welcome, sent him all his exotic fungi, and this he continued to do when he became Director of the Royal Botanic Gardens, Kew, in 1841. All foreign fungi received at Kew passed through Berkeley's hands for the duration of his active work. Many of these were described in *Decades of Fungi* (1-62, 1844-56).

From 1836 to 1843 Berkeley issued his *British Fungi* consisting of 350 specimens to illustrate *English Flora*.

Berkeley's keenness in microscopy led him quite naturally to take an interest in the structure of the larger fungi. The arrangement of the spores on the basidium was long overlooked in the belief that asci so clearly figured by Hedwig in Discomycetes in 1784 were to be found in all fungi with a hymenium; the quaternate arrangement of spores as figured and described in 1729 by Michelii in what was probably a species of *Panaeolus* was explained away as being the spores of contiguous asci seen end on. Berkeley in *English Flora*

had mentioned the quaternate arrangement in several agarics with dark coloured spores: in *Agaricus (Clitopilus) prunulus* he described the gills as "covered with very minute papillae ending in four spiculae. Spores . . . often seated upon the spiculae." As sometimes happens in scientific matters several investigators independently turned their attention to this problem. Ascherson in a short note in 1836 mentioned the general occurrence of what Léveillé later called basidia in the 'higher fungi'. Léveillé in the following year gave a full account of the structure of the hymenium in Basidiomycetes and contrasted it with that in Discomycetes. In 1838 Berkeley independently found basidia in all the Hymenomycetes. He examined and followed this up the next year by extending the observation to Gasteromycetes. *English Flora* was published before doublets were invented, which is always to be taken into consideration with older performances.[1]

When they heard that Berkeley was writing the account of fungi for *English Flora,* the sons of J. E. Sowerby (who had published *Gleanings*) approached him with the idea of issuing an octavo edition of their father's plates with additions which, together with those in the *Scottish Cryptogamic Flora,* would include all the species of cryptogams described in *English Flora.* Berkeley was very keen on the project for fungi. He sent specimens and vetted drawings. The work dragged on and even after a prospectus was drawn up in 1840 no real steps were taken and the scheme was finally dropped in 1852—so many additional plates were required that the enthusiasm of the artists and publishers was first damped and then extinguished.

Meanwhile between 1834 and 1849 Berkeley had contributed descriptions of 36 algae (two in collaboration with G. H. K. Thwaites) to the *Supplement to English Botany* Vol. II-IV; his name appears as a collaborator on the title page of Vol. IV.

The publication of *English Flora* opened up another line for Berkeley. He was asked to write a paper for the first number of the *Magazine of Zoology and Botany* (afterwards *Annals and Magazine of Natural History*), and 'Notices of British Fungi' was the result: in all 35 instalments of this appeared (1837-1885), C. E. Broome collaborating from number 8 (1848).

From the first Berkeley was interested in fungi as organisms, but had this not been true, he would have been led irrevocably to his

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[1] Berkeley worked with doublets until 1868 when J. D. Hooker presented him with a Smith and Beck compound microscope.

wide outlook since many took advantage of his mycological knowledge. When Lindley, Kane, and Playfair were appointed by the government to enquire into the potato murrain they were 'only too glad to avail themselves of Mr. Berkeley's invaluable assistance.' Thus originated Berkeley's first contribution to plant pathology which conclusively controverted the prevailing view which Lindley voiced: "I am perfectly satisfied that fungi do not *cause* it; though God knows they follow it fast enough." His second contribution, in 1847, was on *Oidium Tuckeri* which was attacking grapes in the neighborhood of Margate. He noticed the absence of *Erysiphe,* and suggested that the *Oidium* was not simply an early stage for its spores reproduced itself, but that there might be an alternation of generations such as was known in the animal kingdom—the first suggestion that this phenomenon might occur in plants. He advised Edward Tucker, the gardener who had called attention to the disease, to try the application of sulphur as a remedy.

The authority 'B & Br.' is one of the best known in mycology. Though the combination did not occur until 1848 the association began seven years earlier. C. E. Broome, then studying with a curate in Cambridgeshire with a view to holy orders, met Leonard Jenyns who was the curate of a neighbouring parish. In 1841 Broome, at Jenyns's suggestion sent drawings of an alga and some moulds to Berkeley for his opinion. In a postscript to a second reply Berkeley asked Broome, who had written from Wiltshire, "are truffles found in your neighbourhood?" Broome characteristically set about getting all the information he could. From such a start he had so far advanced that in 1844[2] Berkeley proposed a joint paper on subterranean fungi but it took four years for Broome to be persuaded of his competency. The correspondence covers forty-five years. Broome's letters are more strictly mycological, except for occasional outspoken comments on politics, whereas Berkeley's often give interesting remarks on more general matters.

After his period of apprenticeship Broome took more and more interest in fungi generally, collaborating first with the 'Notices' and afterwards in other ways, Berkeley writing the papers and taking chief responsibility. Later, as Berkeley began to lose his powers of intense application, Broome took over more of the work, Berkeley

[2] Two months after Broome's reply Berkeley wrote: "I have just dedicated to you a magnificent new genus of Fungi a compound Geaster from the Cape. Nothing could be more curious." In his next letter he gives the name *Broomeia congregata*: "it is one of the most curious and distinct genera amongst Fungi."

occasionally doing little else than editing. Broome usually sent his own finds with descriptions and microscopic details: Berkeley often sent his specimens to Broome for microscopic examination, half to be retained if there was sufficient material. Broome usually paid a visit to Berkeley for the writing of the paper.

From 1848 large numbers of exotic fungi were sent to Broome "to make my letters worth opening." Collaboration in publication on exotic fungi began in 1867 with specimens from Ceylon sent by Broome's friend G. H. K. Thwaites. This was followed by a series on Queensland Fungi.

Another fruitful collaboration was that with M. A. Curtis. In April 1846 Curtis "relying on the kindly feelings which I have ever found to characterize the student of Natural History" asked for Berkeley's "sympathy, correspondence and exchange of specimens." The correspondence thus began went on until 1872 with a break during the Civil War. In 1852 there was mention of a volume on North American Fungi and in 1853 Berkeley approached the Smithsonian Institution. The gist of the reply was that the Institution would be happy to consider a completed manuscript though from information sent from Curtis they would publish parts if they were complete in themselves so that failure to print the whole would not affect the value of what was published. The fact that there was to be no payment probably was a factor in deciding Berkeley not to press the matter but to continue naming the collections as they arrived. Curtis's numbers as given in his letters reach 4,903, but Berkeley estimated that he had received "more than 6,000." Curtis was such an apt pupil that he published *Contributions to the Mycology of North America* in 1848. Berkeley and Curtis collaborated in an account of the exotic fungi of Schweinitz's herbarium in 1854, of the fungi of Wright's North Pacific Exploring Expeditions in 1858, and in descriptions of Curtis's collections.

Curtis sent many specimens collected by his neighbour H. W. Ravenal but protected Berkeley as far as possible from direct communication: he also sent specimens from his numerous American correspondents.

A work which added much to Berkeley's reputation was an *Introduction to Cryptogamic Botany,* a volume of 600 pages and 127 of his own illustrations, which was published in 1857. The method of presentation is not of the best but the book is a store-house of information and, being the first of its kind, probably more thought was given to subject matter than to arrangement.

Outlines of British Fungology with 442 pages and 24 plates appeared in 1860. This gave an account of the larger forms but only generic descriptions with lists of species of the microfungi. It was originally intended that the book should be on the lines of Badham's *Esculent Fungusses of England* but unfortunately this was not adhered to, and so instead of what would doubtless have been an erudite semi-popular book with assuredly wide appeal there resulted a "bookseller's work" based largely on *English Flora.* Berkeley had hoped that the publishers would undertake a popular monthly dealing with fungi, but they preferred to commission him to write a *Handbook of British Mosses* which appeared in 1863. Though this work was not of very great merit it played a large part in popularising the study of mosses as it was the cheapest manual available and dealt with the group in its entirety.

According to his preface to M. C. Cooke's *Fungi: their nature, influence and uses,* 1875, Berkeley was asked to undertake the writing of it but being much occupied and in uncertain health recommended Cooke. Berkeley's name is given on the title page as editor. There seems to be no correspondence with Cooke during the writing of the book though Berkeley had jotted down chapter headings on the back of one of Broome's letters. Berkeley disliked Cooke but apparently had noted some of his popular articles and—there was no one else available.

For almost half a century Berkeley was the recognised British authority on all matters connected with mycology, and nothing concerning fungi seemed to escape his net. Thus it was that he had a good deal to do with demolishing the suggestion that cholera was caused by fungi and was steadfast in opposing all support in favour of Hallier's phantasies on diseases and spontaneous generation. His Presidential address to the Biological Section of the British Association at Norwich in 1868 largely deals with these matters. In addition to a very considerable number of purely systematic papers there are many dealing with the impact of fungi on various aspects of life. A long stream of semi-popular articles flowed from his pen for the *Intellectual Observer, Sporting Gazette* and the *Gardener's Chronicle;* to the last-named he also contributed more strictly scientific papers, being a regular contributor for over forty years. He wrote the section on fungi in several works including J. Lindley's *The Vegetable Kingdom,* on diseases of crops in J. C. Morton's *A Cyclopedia of Agriculture* (2nd edition), and articles on fungi and algae in J. W. Griffith and A. Henfrey's *The Micrographic Dictionary* (2nd edition)

and J. Lindley and T. Moore's *The Treasury of Botany*.

Berkeley was certainly interested in imparting knowledge but this was not the driving force; it was to provide for his large family —thirteen of his fifteen children reached adolescence. In addition he had the cares of their preliminary studies added to by coaching those who were competing for service appointments.[3] For many years he and his wife kept a school for boys but had to give it up in 1849. His ministerial duties were heavy and he took them seriously and he could ill spare the two days a week in London which his post at the Royal Horticultural Society necessitated. After Lindley's death in 1865 he acted as botanical adviser to the Society and chairman of its Scientific Committee, and edited the Society's Journal from 1866 to 1877. He occasionally did translating and editing. He was a sound Latin scholar and was paid to revise the descriptions in Bentham and Hooker's *Genera Plantarum*. He did a considerable amount of examing chiefly for the Indian Service, the Apothecaries Society and the London University, keeping it up until he was over seventy. In spite of his appearance he did not have good health but was constantly suffering from gout, calculus, and overwork; in his letters there is frequent reference to illness of one sort or another which kept him inactive for weeks.

Through his connection with the Royal Horticultural Society, the *Gardener's Chronicle*, and the plant-disease work, Berkeley acquired a very wide knowledge of plants and their cultivation and products; tributes to his proficiency are frequent in the letters of his contemporaries.

Thiselton Dyer, who was prominently associated with the introduction of the so-called *New Botany*, in speaking of the botanists of the period says that Berkeley was "a remarkable and isolated figure." It is interesting to speculate what the effect would have been on botanical teaching if J. S. Henslow's wish that he should succeed him as Professor of Botany at Cambridge in 1865 had materialised. Berkeley was persuaded that resident members of the Senate would favour C. C. Babington so he did not apply. Two years later he was pressed to apply for the Sherardian Professorship at Oxford in succession to C. G. B. Daubeny. He exerted himself in the hope of being appointed but it was legally decided "that a clergyman is not eligible . . . so there is an end to the matter."

[3] His eldest son Emeric entered the Army and served in India attaining the rank of Major General. He sent home the interesting fungus *Emericella* shortly after his arrival. He became an authority on Indian orchids.

His pre-eminence in Mycology[4] and his several good qualities brough him little advancement in the Church and signally few scientific distinctions. The French Government awarded him a prize of 500 francs in 1857 for his studies on vine mildew. He received the Gold Medal of the Royal Society of London in 1863 in recognition of being "the most eminent living author" in Mycology but was not elected Fellow until 1879. This is strange for he was apparently *persona grata* with all the foremost botanists of his day and was not of the type that is occasionally frozen out for the general comfort of the elect. He was awarded a Civil List Pension of £100 a year in 1867 for his services to botany with special reference to plant diseases, and set up a little pony chaise on the strength of it.

When by 1879 he felt that his main days of study were over he arranged his collections and presented them to Kew. They were said to comprise 10,000 species with 5,000 of his types. But 'B & Br.' continued till Broome's death in 1886.

In his youth Berkeley looked like 'a substantial yeoman' but as years went on he acquired a more benevolent appearance. His head reminded Curtis "somehow of Benj. Franklin." Until after his seventieth year he had a full beard as in the portrait presented to the Linnean Society of London in 1878; afterwards he was clean shaven. He was ever courteous and practised what he preached.

Mycology and plant pathology had little or no place in academic botany in this country until recent years so Berkeley was rarely considered when attempts were made to write botanical history. Now that circumstances are changing it is probable that his true worth will be more readily acknowledged.

—John Ramsbottom

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[4] "Desideratissima vero Synopsis Hymenomycetum extra-europaeorum, qualem solus praestare valebit Rev. Berkeley." E. Fries, Hymenomycetes Europaci, 1874.

Observations, Botanical and Physiological, on the Potato Murrain

By the Rev. M. J. Berkeley, M.A., F.L.S.

(*The Journal of the Horticultural Society of London,* vol. I, pp. 9-34, 4 plates, 1 text-figure, 1846.)

Few subjects have attracted more attention, or have been more variously canvassed, than the malady with which Potatoes have been almost universally visited during the autumn of 1845. The press has teemed with notices the most contradictory; the attention of scientific men in every direction has been engaged by it; and three, at least, of the principal governments of Europe have issued commissions to examine into its etiology, and to discover, if possible, a remedy.

It is not indeed the first time that very serious disease has existed in this important article of food: more than half a century back, cultivators were much alarmed by a disease known under the name of the Curl, which committed at that time immense ravages, and is even now, especially in the North, a very formidable evil. It consists in a sudden check of growth in the young shoots, and, in consequence, a failure of produce. As is the case with so many diseases of plants, the cause is very imperfectly known.

In 1830 a disease was first noticed in Germany, called, from one of its leading features, the dry rot. For several successive years it was observed to increase in intensity, threatening to put an end to the cultivation of potatoes in the affected districts. The attention of the Bavarian Government especially was called to the subject, and Martius has published an admirable account of it.[1] The tubers, when stored for winter use or when planted, become impregnated with a kind of mould, and are at length so hard that they can scarcely be broken, and, instead of producing shoots, merely throw out a few small misshapen tubers. He attributes it to the growth of a peculiar fungus.

[1] Die Kartoffel-Epidemie. München, 1842.

A somewhat similar disease, but differing in the circumstance that the tubers become soft instead of hard, has certainly been prevalent for many years without attracting much attention, and is probably more or less mixed up with the particular disease to which so much consideration has of late been paid. It is marked by the presence of parasitic fungi, which for the most part appear under the form of hemispherical masses bursting through the cuticle, and is referred by Fries to his genus Periola. The earliest record I am at present acquainted with of the existence of this genus is in 1815, in which year it was characterised by Fries[2], for the plant of Tode[3], to which he refers, published in 1790, is, I think, clearly something different, occurring on the stalks, and not on the tubers. In this disease the tubers, though apparently healthy when stored, are rapidly destroyed by the fungus.

Another disease, arising from a very different fungus, is frequent, especially in calcareous districts, and is known commonly by the name of the scab, the surface of the potatoes being covered with pustules, which at length become cup-shaped, and are powdered within with an olive-yellow meal, consisting of the spores of a fungus. This also has been partially investigated by Martius, who has illustrated his observations with some characteristic figures.

Two other diseases are mentioned in the work of Martius, which are, however, so imperfectly known, that it is not neccesary to notice them upon the present occasion.

In all the cases referred to above, the disease has either been confined principally to some one country, or, if more widely diffused, its effects have not been of such magnitude as to excite any general fears; whereas, in the present instance, the whole of Western Europe, from Norway to Bordeaux, seems almost equally to have suffered, and the ravages have not been less in Canada or the Northern parts of the United States of America. It is probable that it has existed for some time without attracting much attention: at any rate it is not the birth of one year only, as the advocates simply of atmospheric influence suppose. Dr. Morren[4] informs us in his admirable little pamphlet that it has been known for two or three years in Belgium. It appeared in the province of Liège in 1842, and on the 24th of March in the following year he laid before a large assembly of

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[2] Fries, Obs. Myc., vol. i. p. 205.

[3] Fungi Meckl. Fasc. i. p. 6, 1790.

[4] Instructions populaires sur les moyens de combattre et de détruire la maladie actuelle des Pommes de Terre. Bruxelles, 1845.

landowners its history, and the means of contending against it. Were this testimony by itself, we could not refuse to take it at the mouth of one who has paid so much attention to the subject, and is so intimately acquainted with all the phases of the disease. But the testimony is far from being solitary. In an excellent article in a Lille paper of the 26th of September, kindly forwarded to me by Monsieur Desmazières, it is stated that the disease of 1845 is identical with that which he described in a Memoir presented in the latter part of 1844[5] to the Royal Society of Lille. The volume of the Transactions of that Society, even for 1843, has only just appeared; I applied therefore to the author for an abstract of his paper, which he sent me with his accustomed kindness. The disease was not observed when the potatoes were harvested, but appeared towards the end of the year. M. Desmazières considers it as certain that the malady was identical with that of 1845. As however he had no opportunity of examining all the appearances presented by the disease, and no traces of the peculiar mould which uniformly accompanies it, at least before the putrescence of the tubers was visible, though other fungi were very abundant, this case perhaps may not be thought quite so convincing as the former; or at least it may, with all deference to the excellent author, be surmised that it was greatly modified by the presence of a distinct disease in company with it.

Mr. J. E. Teschemacher[6], in a letter to Mr. Colman, the Agricultural Commissioner from the State of Massachusetts, attributes the potato disease of 1844 to a fungus. This opinion was, I believe, more fully stated in a Memoir published at Boston, by the same author for which Dr. Morren, in a letter dated October 25, refers me to the official reports of the United States, but to which, unfortunately, I have no access. Mr. Teschemacher indeed compares the fungus to the smut in corn; but taking other documents into consideration, it does not appear that this is to be interpreted rigidly. The disease, beyond all doubt, was very prevalent in Canada and the adjoining parts of the United States in 1844.[7]

The best account of the disease of Canada in 1844 is in a letter to Dr. Bellingham, which was read by him before the Dublin Natural History Society on the 14th of November, 1845, and published, to-

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[5] The exact title of the Memoir is 'Recherches sur l'altération observée dans le tubercule de la Pomme de Terre grise cultivée dans l'arrondissement de Lille en 1844.'

[6] Gardiner's Chronicle, 1845, p. 125.

[7] Ib., p. 648.

gether with much important matter from himself and Mr. W. Andrews, in 'Saunder's News Letter' of November 17:—

"During the months of July and August we had repeated and heavy showers, with oppressive heat, and an atmosphere strongly charged with electricity. Towards the close of the month of August I observed the leaves to be marked with black spots, as if ink had been sprinkled over them. They began to wither, emitting a peculiar offensive odour; and before a fortnight, the field which had been singularly luxuriant and almost rank became arid and dried up, as if by a severe frost. I had the potatoes dug out during the month of September, when about two-thirds were either positively rotten, partially decayed and swarming with worms, or spotted with brownish coloured patches, resembling flesh that had been frost-bitten. These parts were soft to the touch, and upon the decayed potatoes I observed a whitish substance like mould." This was clearly an aggravated form of the disease of 1845.

It is stated by Mr. Elliott[8], of Florence Court, that the disease has been for the last three or four years prevalent in that part of Ireland; and Mr. Smeed, an eminent agriculturist of Bromston, near St. Peter's, in the Isle of Thanet, observed it in 1844.[9] It is not improbable that the disease which made its appearance in St. Helena, in 1844,[10] was really identical, and it is possible that the rust observed by Staudinger[11] at Hamburgh some years since, was the same, if it be not rather referable to the disease mentioned by Martius under the name of Rust, which, though in some respects resembling that before us, differs too widely to allow of their being considered the same. It is impossible, indeed, to form any accurate judgment where the details are so imperfect and insufficient.

In a recent communication to the French Academy, Nov. 17, 1845, M. Boussingault states, on the information of M. Joachim Acosta, that the malady is well known in rainy years at Bogota, where the Indians live almost entirely on potatoes. They do not hesitate to use them, merely cutting off the affected part. M. Acosta believes that the disease has been always familiar to the Indians[12].

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[8] Gard. Chr. 1845, p. 674.

[9] Ib.

[10] Gard. Chr. 1844, p. 359.

[11] Isis, 1832.

[12] L'Institut, Nov. 19, 1845. This singularly confirms Dr. Morren's notion that the disease, like some other afflictions of the vegetable kingdom, is of American origin.

It seems then clear, from the instances adduced, and others possibly may be found which have escaped my observation, that the disease cannot be considered as confined to the year 1845; and therefore, in endeavouring to ascertain its causes, it is absolutely imperative to keep this fact in view. The details are not indeed always sufficient, from the very nature of the case, for us to form a judgment from them ourselves; but putting all the information together, and properly estimating the parties from whom the evidence springs, we cannot fail to assent to their combined testimony.[13]

The first notice of the disease in any of our own journals was by Dr. Bell Salter in the 'Gardeners' Chronicle' for August 16, p. 560, [1845], when it had become so prevalent in the Isle of Wight as to attract general notice and to excite great alarm. It had doubtless made its appearance some weeks previously, but probably not so early as in Belgium, where it was observed about the 10th of July, and on the 18th of August it had been so fully discussed that Dr. Morren, following the track of Dr. Van Oye and Mlle. Libert, published in the Belgian 'Indépendance' of that date a very full account, and suggested remedial measures. If one of these had been followed generally, viz. removing at once the diseased haulm, it is, I think most probable that we should have heard little more of the disease.[14]

A week after Dr. Bell Salter's first notice it was pretty general in the South of England, for on the 23rd of August few sound samples of potatoes were to be found in Covent Garden market, and Dr. Lindley had been able from personal observation to write the excellent article to which we shall presently have occasion to advert. The first public notice taken of the subject at Paris, as far as I can discover, was at the Société Philomathique on the 30th of August, when the subject was introduced by Dr. Montagne, a few days before any communication had been made at the Academy. Since this period up to the present time it has been the subject of constant investigation.

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[13] The Brussels Commission, however, came to a different conclusion. See 'Rapport fait au Conseil Central de Salubrité Publique de Bruxelles sur la Maladie des Pommes de Terre, par M. Dieudonné, rapporteur.' They were, evidently, not in possession of all the evidence which has just been adduced. M. Durand, of Caen, does not consider the disease a new one.

[14] The evidence indeed is somewhat contradictory on this point, but preponderates greatly in favour of the practice. The fact that diseased tubers occur sometimes before the haulm is much affected shows that it would not have entirely arrested the malady.

The disease then appears to have commenced in Belgium and to have radiated from thence, taking a gradual progress to the north and west, when it had become established in the south. On the 30th of August it was not known in the midland counties, though a few days after it was very general. It commenced in Ireland about the 7th of September, and somewhat later in Scotland. At the end of October Dr. Bell Salter informs us[15] that the disease was making its appearance in young plants.

Opinions of the most contrary description have been advanced respecting the cause of the disease, some attributing it entirely to the peculiar season, which, granting it to have been exactly such as the advocates of this notion assume, might more readily be admitted were it not certain that the malady has been prevalent even to a great extent in one season at least very different from that of 1845;[16] others refer it to electric influences, to microscopic insects, to an epidemic resembling cholera, to the practice of raising potatoes constantly by division of the tubers, and especially from tubers cut in spring, to the use of animal manure, or to the degeneracy of the plant itself, but without any data upon which to found their assertions: others, again, to the influence of a parasitic fungus which first attacks the leaves and ultimately the tubers. Before reviewing these opinions it will be well to describe the phases exhibited by the disease, reserving to the end of the memoir the more purely botanical points connected with the subject. The chemical part of the question does not fall within my scope, and the remedial measures have been already exhibited in a form generally accessible to English readers in the reports of the Irish Commissioners.

The progress of the disease has been described in almost the same terms by all who have written on the subject. It was at first indeed believed by many that it began in the tubers and was propagated upwards, but every one seems pretty well convinced at present that the order of events is precisely contrary; for though it is true that in diseased fields a few scattered tubers, principally if not entirely such as chance to be superficial, may occasionally be found, or even a diseased tuber, on a plant whose leaves and stalks are apparently healthy,[17] yet these are quite exceptional cases, the general fact

[15] Gar. Chron. 1845, p. 742.

[16] Up to the 28th of September the mean temperature of 1845 was nearly three degrees below that of 1844; the quantity of rain during the corresponding period of 1844 being scarcely more than half the average.

[17] Revue Botanique, 1845, p. 150.

being that, at the time the foliage first becomes diseased, the tubers are healthy.

The potato crops up to a certain time were very luxuriant, as testified indeed by the produce in spite of the premature decay of the organs on which of course the perfection of the crop depends. This was especially the case with the crops which were attacked in Canada in 1844, and Dr. Bellingham informs us that in Ireland there was "a luxuriance of the leaves, flowers, and stalks, which led most people to suppose that there would be an unusual yield." The luxuriance perhaps indicated the latent disease in accordance with the phenomena presented by corn affected by cereal fungi.[18] The leaves then began suddenly to assume a paler and at length a yellowish tint, exhibiting here and there discoloured spots, and, if I mistake not, were less copiously clothed than usual with pubescence on the under surface. More or less exactly coinciding with these spots on the reverse of the leaves appeared white mealy patches, consisting of a minute mould proceeding, either singly or in fascicles, from the stomata, and arising from an abundant branched mycelium creeping in every direction through the loose tissue beneath the cuticle. The upper surface rarely if ever exhibits the mould, it being almost physically impossible for its delicate threads to penetrate the closely packed cells which, being arranged side by side, leave scarcely any intercellular passages. The mould in a few hours from its first piercing the apertures of the stomata perfects its fruit, and in so doing completely exhausts its matrix, which in consequence withers. No sooner have a number of the leaves been attacked than the stem itself is subject to change, becoming spotted here and there with dark brown patches in which the cells are mostly filled with a dark grumous mass, without exhibiting any mucedinous filaments, though occasionally, as in a portion figured, I have ascertained their presence. Very rarely fructifying but dwarfed specimens of the mould occur upon it. I have figured such, as sent to me from the neighbourhood of Bristol by Mr. Broome. The stem now rapidly putrifies, the cuticle and its subjacent tissue becoming pulpy, and separating when

[18] It is well known that the presence of the mycelium of fungi acts as a stimulant to the chlorophyl; witness the rich tint of fairy rings. A curious instance has within a few days fallen under my notice. The hazel leaves a week or two back were very generally spotted with dark patches of green. On examination it was found that the reverse of such patches was covered with Erysiphe guttata, which had been living at the expense of the paler portions of the leaf, while in the superjacent patch the chlorophyl had become of a deeper green.

touched from the woody parts beneath. The whole soon dries up, and, in many instances, exhibits in the centre the black irregular fungoid masses which are known under the name of *Sclerotium varium*,[19] and which are believed by the most competent authorities to be the mycelium of certain moulds in a high state of condensation.

If the tubers are now examined, the greater part will often be found smaller than usual, especially if the disease has commenced at an early stage of growth, but in their natural condition, while here and there a tuber, particularly if it has chanced to be partially exposed, exhibits traces of disease. The surface is, however, soon marked with livid patches, commencing generally about the eyes, or at the point of connection with the fructifying shoots, according to Payen and Phillips; these rapidly acquire a spotted appearance, the spots being rather waved, and assuming often a more or less concentric arrangement. Sometimes, especially on the smoother kinds of tuber, two or more regular systems of concentric spots are exhibited on the same tuber. The skin now withers, and is easily separated; the spots become depressed, and of a yellowish tinge; and if the tubers be laid in a moist place, in a day or two—sometimes in the space of a few hours—the same mould which destroyed the leaves springs from them, piercing the cuticle from within, yet not scattered, as on the leaves, but forming a conspicuous white tuft. If a section of a diseased tuber be made on the first symptoms of the disease, little brownish or rusty specks are found in the cellular tissue, confined, with very rare exceptions, to the space between the cuticle and the sac, if I may so call it, of spiral vessels and their accompanying tissue, which, springing from the subterranean branches, pass into the tuber, making their way to the several buds disposed on the surface. The disease, I believe, commences in the mother cells of the fecula, and not in the empty subcuticular cells, or in the cuticle itself, though the contrary has frequently been stated. These spots consist at first of a quantity of discoloured cells mixed more or less with others in a healthy condition. The walls are tinged with brown, and sprinkled both within and without with extremely minute inorganic granules, which Monsieur Decaisne[20] has found to resist the action even of concentrated boiling muriatic acid. The grains of

[19] This has been the case very generally. I have received specimens from Mr. J. D. C. Sowerby, procured near London; from Suffolk by Professor Henslow; from Dumfrieshire by Sir W. Jardine; and from Elgin by Mr. Robert Arthur, who communicated them to the London Horticultural Society.

[20] Revue Botanique, 1845, p. 161.

fecula, which are themselves sometimes powdered with the brown bodies, are for a long time perfectly healthy, without any laceration of their walls or change of colour, and are never, as in the disease of Martius rough with incipient fungi. The cells themselves, so far from being looser, are more closely bound together than in the more healthy portions. In general, no traces of mycelium are visible in this stage, but I have found in the midst of the patches in some of the cells, usually in those less diseased, young plants of mould springing from the walls within, exactly as Martius[21] has figured the incipient Fusarium in the disease which he has called Dry Rot. The processes on the cells, which Payen took for mycelium, exist not only on the diseased cells or on the sounder cells of the diseased tubers, but I have found them also in potatoes of 1844, and in tubers produced from them in the cellar; and there appears to be something analogous on the mother cells of other plants, as in those of the tulip and *Arum maculatum*. Their resemblance, however, to mycelium, from their mode of growth, and occasionally somewhat dichotomous habit, is so strong that is it very difficult to divest oneself of the notion that they are really of a mucedinous character, especially when Payen's chemical analysis, corresponding so closely with that of fungi, is taken into consideration.[22] The rusty spots soon exhibit a darker tint, spreading in every direction, and becoming confluent; they at length extend beyond the barrier of vascular tissue, and attack the central mass. The tuber, meanwhile, assumes a disagreeable smell, decomposes more or less rapidly, other fungi establish themselves on the surface, or in the decaying mass, which emits a highly foetid odour resembling that of decaying agarics, the union of the cells is dissolved, animalcules or mites make their appearance, till at last the whole becomes a loathsome mass of putrescence. The eyes[23] are usually the last part destroyed, from the disease being peculiar to the cellular tissue, and not very readily spreading beyond it: and, in consequence, extremely decayed tubers will, when planted, vegetate and produce healthy shoots, which support themselves as the decay of the mother plant proceeds by their own roots.[24] Meanwhile, the traces of mycelium are sometimes more evident, though

[21] Martius, Die Kartoffel-Epidemie, Tab. 3, fig. 18, 21.

[22] In the supposed fungous substance he found 9.75 per cent. of azote, while mushrooms from the bed contain 9.78.

[23] The eyes of the decayed tubers often show a remarkable tendency to shoot. I believe this is the case principally in such specimens as have been exposed to light.

often extremely obscure: but the walls of the cells, when divided, often take so tortuous a course, assume so many forms, and are so confused by the brown granules, that it is extremely difficult to distinguish any mycelium from them and no appearance can implicitly be trusted, except when the threads are seen to float freely on the edge of the portion examined; and even where this has been satisfactorily ascertained in a portion of a slice taken immediately below one of the tufts of mould, it is very difficult to perceive it on another. Indeed, on examining the diseased spots on the smooth surface of a divided potato which had given rise to an abundant harvest of the Botrytis, though the mycelium was clear enough at the edge of a thin slice, it was almost impossible to trace it farther, from the confusion caused by the various septa, either divided by the lancet, or seen through the superincumbent tissue. I have seen one case only in which the spots did not give rise in the first instance to the peculiar mould; but this was in a specimen already highly diseased and partially putrescent. In an earlier stage of the disease the Botrytis is uniformly produced, and at the time of writing these notes (Nov. 22nd) I cannot find, in my potatoes which have been kept dry, any other species of mould except on portions injured by the fork, which exhibit some of the commoner species, and on parts which have been bruised, on which there is a minute mucor. It is plain, that at a late period of the disease, when other fungi have been established, and on breaking the tuber mucedinous patches are visible within, all traces of the original parasite may easily be lost. But even in this state it should seem that there is some difficulty occasionally in tracing any mycelium amongst the cells, as Monsieur Desmazières, a most practised microscopic observer, had not, even so late as the 17th of January—though the tubers he examined were eaten up with a Fusarium—been able to detect any mycelium.

The order of phenomena described above is such as to show a very intimate connection between the parasite and the disease. Accordingly, the notion that the disease is the effect of the parasite has met with some advocates, especially in Belgium. Monsieur Payen also, to a greater or less extent, accords with Dr. Morren: and, after an

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[24] It remains to be seen what will be the ultimate condition of these plants. I do not apprehend that the decayed tuber beneath will injure the plants when they are once established; but the shoots if not produced rapidly sometimes fail, partly, as it should seem, by immediate imbibition of diseased juices, partly from the contiguity of diseased matter. See 'Gardiner's Chron.,' 1845, p. 768, c., for some observations bearing on this subject.

attentive consideration of the progress of the disease and of almost everything of value that has been written on the subject, and after duly weighing the peculiar difficulties with which it is attended, I must candidly confess, that with a becoming share of philosophic doubt where such authorities are ranged upon the opposite side[25], I believe the fungal theory to be the true one. I cannot claim the support here of my friend Dr. Montagne, though he has been imagined by some of his colleagues to accord in opinion with Dr. Morren; but in the very first communication I had from him upon the subject he expressly stated his doubts as to the true cause of the disease, though at the same time he admitted its intimate connection with parasitic fungi.

To avoid going twice over the same ground, it will be convenient to consider first the other opinions which have been brought forward.

The principal advocates of the opinion that the disease is in the first instance independent of parasitic fungi, and that it arises from the peculiar atmospheric conditions of the season, are the members of the Brussels and Groningen Commissions; Dr. George, Dr. Vallez, and De Potter, in Belgium; Bouchardat, Decaisne, Desmazières, Duchartre, Morren of Rennes; Philippar and Pouchet in France; Drs. Kützing and Munter, in Germany; and in the British dominions, Drs. Kane, Playfair, and Lindley, Dr. Bellingham, Mr. W. Andrews, and Mr. G. Phillips. The matter is differently expressed by different parties: some speaking principally of excessive moisture; others of alternations of heat and moisture; others of the peculiar electric phenomena; and all, more or less, of the surcharge of the cellular tissue with moisture. It will not be necessary to examine the views of each separately, because they all tend essentially to the same point. Those of M. Decaisne, unfortunately, have at present only been partially stated. I regret much that his memoir will not appear until these observations are in the printer's hands.

Dr. Lindley stated the matter very clearly in the 'Gardener's Chronicle' for August 23, [1845, p. 575] in a passage which I proceed

[25] Monsieur Duchartre, in the 'Revue Botanique,' 1845, p. 177, states that I have modified the notions which I at first entertained of the Botrytis being the cause of the disease, founding this assertion on my correspondence with Dr. Montagne. There is certainly some mistake in this. I may have expressed myself as open to conviction, and acknowledged, as I still do, the difficulties of the case; but at present I have certainly seen no reason to depart from the opinion I formed from the moment I had an opportunity of examining the matter for myself. My first communication to the 'Gardiner's Chronicle' was made before I had an opportunity of seeing the disease in situ.

to copy. It is to be remembered that it was written at an early stage of the inquiry, but his views have suffered scarcely any alteration, notwithstanding the great attention he has since given to the subject.

"The cause of this calamity is, we think, clearly traceable to the season. During all the first weeks of August the temperature has been cold, from two to three degrees below the average—we have had incessant rain and no sunshine.

"The potato absorbs a very large quantity of water. Its whole construction is framed with a view to its doing so; and its broad succulent leaves are provided in order to enable it to part with its water. But a low temperature is unfavourable to the motion of the fluids or to the action of the cells of the plant; and, moreover, sunlight is required in order to enable the water sent into the leaves to be perspired. In feeble light the amount of perspiration from a plant is comparatively small; in bright sunshine it is copious: in fact the amount of perspiration is in exact proportion to the quantity of light that falls upon the leaf. At night or in darkness there is no appreciable action of this kind. During the present season all this important class of functions has been deranged. The potatoes have been compelled to absorb an unusual quantity of water; the lowness of temperature has prevented their digesting it, and the absence of sunlight has rendered it impossible for them to get rid of it by perspiration. Under these circumstances it necessarily stagnated in the interior; and the inevitable result was rot, for a reason to be presently explained. If the first days of July had not been suddenly hot, it would not have happened; and perhaps it would not have occurred had the temperature been high instead of low, even although the sun did not shine and rain fell incessantly. It is the combination of untoward circumstances that has done the mischief."

"It may be urged perhaps, in opposition to this explanation, that potatoes thrive very well in districts whose summers are usually as unfavourable as this has been; as for example the cold parts of Scotland. And that is doubtless true. But in those climates the potato grows slowly, its tissue becomes thoroughly organized as it proceeds, and it is not liable to be acted upon by accumulated moisture. There no predisposing cause exists. But in England the potato was predisposed to take the disease which is destroying it by the unusual warmth of the beginning of July suddenly succeeding a period of cold, ungenial weather; at that time the temperature of the soil near London was between 60° and 68°; the potatoes grew

excessively fast, their tissue was soft and unconsolidated, filled with azotized matter, as all such tissue always is, and peculiarly liable to run into a state of rottenness."

The most complete statement after this is in a pamphlet by Dr. Vallez and De Potter. I have not been able to procure the original pamphlet, but, by the kindness of Messrs. Desmazières and Decaisne, I have received extracts from the 'Moniteur Belge' of the 29th of August, and the Belgian 'Précurseur' of the 16th of September, 1845, which contain, evidently, the most important portions of the pamphlet. It will be well to give an abstract, as the matter is stated somewhat differently by these authors.

The earth at the commencement of June, they say, in consequence of its dryness and the extreme heat with which it was inundated, its low conducting powers and its negative state of electricity, was necessarily a bad reservoir or general recipient of the fluids just mentioned.

The air, from want of rain, was also a bad conductor, and was, in consequence, surcharged with electricity; but great storms suddenly took place: whilst the air got rid of its excess of electricity, and became, from its humidity, a better conductor, the soil, from being a recipient of the moisture, was in a different condition. It constituted a superficial sponge, in which all the electricity contained in the air was absorbed, producing in it a more violent action, and exciting a sudden and great increase of heat. In consequence of this condition, the tubers became suddenly gorged with moisture, and the prey of putrefaction.

In whatever terms, in fact, from differences of climate or of personal views, the matter may be stated, the exciting cause of the decay is by all considered excess of moisture combined more or less with heat, or electric agency. In addition to the causes mentioned by Dr. Lindley as producing the putrefaction of the stems, even if it be not considered as the immediate cause, the Botrytis would be concurrent in preventing the perspiration of the excess of moisture. For not only does the mycelium block up in great measure the loose tissue which gives a passage to the fluid, but more or less completely the stomata also by which the vapour passes.

As regards electric phenomena, though they are known to have a most important influence on the production of fungi, it is far from clear that they have much effect on phænogamous plants. The experiments lately made on the influence of electricity on vegetation seem to show that it is very small.

Besides the objection stated by Dr. Lindley as capable of being brought forward against his views, it may be urged that the fact of the disease not being peculiar to the year 1845, but having been excessively destructive in 1844, and more or less so in preceding years, greatly militates against the notion of its being due to the peculiar season. For it cannot be asserted that there was much similarity between 1844 and 1845. And, taking the experience merely of 1845, and the various times at which the disease made its appearance in different parts of the country, the same conditions did not exist in all cases. In many districts it made its appearance during the very dry weather at the end of August and beginning of September. Besides, it does not appear that differences of soil have had much weight in the progress of the disease. In many districts it has been found that the potatoes in the driest soils have been affected most. In the fens[26] of Cambridgeshire it has been observed generally that those spots in which the water was not perfectly drained, suffered much the least, and similar accounts have been received from other quarters.

I think, too, it may be doubted whether the season, though extremely cold and ungenial, has really been more wet than usual.[27] Dr. Bell Salter, in a late number of the 'Gardener's Chronicle', writes as follows from the Isle of Wight:—"In this place, where the disease appeared so early, and where indeed it has been so severe, it does not appear to depend on free moisture to the extent which is your opinion of the matter. In the districts of the porous greensand formation, which have generally yielded our best crops, they have this year suffered the most; while in the cold, wet districts of the London clay, and beds of plastic clay, and upper fresh-water formations, the crops have been much less attacked. In one instance, in a clay soil, and where the air had not been admitted by

[26] It perhaps may be objected here that the water being impregnated with peat, acted as a preservative. The experience, however, of various districts shows that the peculiar nature of the soil had, in general, little influence on the disease. No districts suffered more than the dry parts of the fens.

[27] It appears from observations made at Chiswick, as reported in the 'Annals of Natural History', that the quantity of rain from May to September inclusive was below the average of the last eight years: the average quantity of rain during those months being 11.20 inches; while during the same period in 1845 it was 11.12. Neither was the rain in any one month greatly above the average.

	May.	June.	July.	August.	September.
Average of Eight Years	2.02	2.26	2.10	2.26	2.52
1845	2.89	1.36	2.31	2.79	1.77

hoeing up, the potatoes were almost unattacked. From all I can collect in this district, exclusion of air appears to have been the greatest preservative, either by depth of planting or even by agency of free moisture on the surface. Though there has been so little duration, at any time during the summer, of weather free from rain, yet the actual quantity of water which has fallen has been much less than usual. Our springs have been very low, and during the harvest period, when fortunately there was a short continuance of dry weather, the effects of drought were most speedily visible."

It may be doubted, too, whether the water of vegetation has always existed in the tubers in a greater proportion than usual. The quantity of water in potatoes is stated by Boussingault as ranging from 75.9 to 79.4 per cent.; according to Payen it is somewhat lower. My own observations do not show any excess of moisture in potatoes taken from the ground in the month of October, the crop being in an extremely diseased state. They exhibited 74 per cent., the central substance of the tubers giving 73.5. Potatoes from a cellar at the same time, in good condition, gave 77.1. Mr. G. Phillips found on the 2nd of October 75.7 in a sound potato taken from the ground. In another variety he found 78.0 and in a diseased white potato 79.[28] The potatoes after they become diseased, probably when placed in a moist situation, imbibe a certain quantity of moisture.

Did the disease really arise from the water of vegetation existing in too great abundance, and hence inducing putrefaction of the cellular substance, it would be difficult to say why it has not existed to a considerable extent before. This spotted form of decay is certainly not familiar to the cultivator, however long it may have existed, though other forms are.

I think then it is at least plain that no supposed peculiarities of season are sufficient without some more specific cause to account for the general prevalence of this disease.

Some have attempted to account for it by the notion that in consequence of long culture, and from the practice of raising plants from cuttings, not from seed, the species is exhausted and incapable of producing healthy offspring. But this depends upon mere theory, it being more than doubtful whether any species or variety does really become exhausted by long culture or by the practice of using cuttings, however popular the notion may be; and were the notion

[28] Monsieur Stas however asserts that all the potatoes of this year contain less water and starch and more coagulable albumen than usual. He states the water at 82.2. (Comptes Rendus, 1845, p. 694.)

well grounded, whether its degeneracy would produce, and that so suddenly and universally, the effects attributed to it; and the fact that the newest seedling varieties have suffered[29] quite as much as the old ones at once overthrows this theory. Others again have attributed it to over-manuring and the use of guano. But this is contradicted by the fact that all soils were subject to the disease, however poor or rich, and whatever the nature of the manure might be with which the land had been prepared.

It has also been conceived that the disease is a sort of epidemic analogous to cholera, arising from some pestilent emanation or specific poison in the atmosphere affecting the health of the plant. Others again affirm that it is due to microscopic insects wafted by the air. M. Gruby goes beyond the rest, and sees three causes at work at the same time—a parasitic insect, a specific disease, and a parasitic fungus. These conjectures however, it is obvious, are not supported by facts, and cannot be adopted provided other more tangible causes can be assigned with any degree of probability.

We come now to the theory which has been so much canvassed, and which is now peculiar almost to Dr. Morren, unless M. Payen is to be reckoned also as its advocate. Of this opinion, notwithstanding the opposition, and in some instances the ridicule almost, with which it has been assailed, I must, as said above, profess myself at present. I do not mean to say that there are no difficulties in the case, or that weighty objections may not be raised, but I think that these difficulties have been exaggerated, while in other instances the exact question has not been understood. It is agreed that the disease commences in the leaves; and in those instances where the mould has not been observed, it is probable that the decayed foliage was examined too late. In a few hours the fungus has run its course, and in a week or so the greater portion of a field is laid waste so as to make it difficult to get specimens for examination. The decay is the consequence of the presence of the mould, and not the mould of the decay. It is not the habit of the allied species to prey on decayed or decaying matter, but to produce decay—a fact which is of the first importance. Though so many other species have this habit, these have not. The plant then becomes unhealthy in consequence of the presence of the mould, which feeds upon its juices and prevents the elaboration of nutritive sap in the leaves, while it obstructs the admission of air and the emission of perspiration. The

[29] See especially Gard. Chron. 1845, p. 768, where this part of the subject is admirably discussed.

stem is thus overcharged with moisture and eventually rots, while every source of nutriment is cut off from the half-ripe tubers. It would be as reasonable to say, with our knowledge of the nature and habits of the cereal fungi, that bunt, or mildew, or the other allied diseases which affect corn, are the consequence and not the causes of disease. In favourable seasons they are not developed; in unfavourable seasons they spread like wildfire: in one sense, therefore, the atmospheric conditions are the cause, but merely as they stimulate into action the latent pest. The immediate cause of disease is the fungus which preys upon the tissues of the corn. So exactly, in the present instance, as far at least as the aërial portions of the plant are concerned, the Botrytis is the immediate cause of destruction. In some instances it may have been aided by unseasonable frost, but this has certainly not always been the case. The mould indeed would not have spread but from peculiar atmospheric conditions favourable to its growth. What these are it may be impossible to say, but it is a fact well known to every student of the extensive tribe of Fungi, that their growth, and especially their numbers, depend more than all other vegetables on atmospherical conditions, or what Fries has happily called "cosmica momenta." Even the peasant knows this to be the case with mushrooms. Dry and wet summers occur, and both are equally barren; while in other seasons, apparently but little dissimilar, they occur in the utmost profusion. A species will be most abundant for a year or two, and then for a period vanish entirely. It is notorious that this is the case in other parts of the creation, especially amongst insects, peculiar species of which sometimes swarm to such an extent as to baffle the naturalist. In the summer of 1826, for instance, *Vanessa cardui* existed in the greatest profusion in England, and it was traced by Mr. A. Way from England to Nice. The species of late years has been comparatively rare. There is nothing surprising then in the fact of the immense prevalence of a parasitic mould. No one wonders when the hop-grounds are ravaged by their peculiar mildew, because the cultivation of hops is so limited; but if it were as universal and of as much importance as potatoes, the ravages would equally excite attention. It is by these instruments, contemptible in the sight of man, that the Almighty is pleased sometimes to accomplish his ends. Instances like that of the Hessian fly, will readily occur of the immense disproportion between the means and the end.

The peculiar habit of the species, as said above, contradicts the notion of its appearance being the consequence of decay. I have in vain tried to make the spores vegetate, as is so easily done with other species. The spores of *Botrytis Bassiana,* which destroys the silkworms, and certainly is not the consequence, but the cause of the decay, because the disease is readily communicated to the most healthy caterpillars even of other species, vegetate readily[30] upon various substances. I do not assert that others may not have better success; but at present, in whatever way I have tried them, I have not been able to get a single spore to sprout, much less to propagate them upon foreign bodies. I do not know of any single instance in which any of the nearly allied species have been found in any other situation than growing from the tissues of plants; were this ever the case, they could not have been overlooked, as their spores are so much larger than those of other species of the genus. *Botrytis cana* is the only species which approaches them in this respect, but it is distinguished at once by its cinereous flocci and its evident relationship to *B. vulgaris.* The species are in fact as peculiar to the living tissues of plants as are the several species of Puccinia and Uredo, which could not exist, or at any rate be perfected, elsewhere. The mycelium of the cereal fungi is known to exist from the earliest period in corn, and is perfected only under favourable circumstances; and there is every reason to believe that the case is the same with these essential parasites, which certainly do not thrive on putrescent matter, but cause the decay of the matter on which they thrive. The direct observations of Bauer, Corda, and Léveillé, prove merely what a thousand facts indicate, unless, indeed we have recourse to the notions entertained by many of spontaneous or equivocal generation from lanquid or diseased tissues; for the question at last reduces itself to this, which is indeed one involved in mystery, but which, as far as I can judge, wherever the veil is partially lifted up, seems after all to point to the same general laws by which the higher portions of the creation are governed.

To my own apprehension, then, it appears clear at least that the cause of the premature decay and putrefaction of the haulm is to be found in the parasitic fungus, in consequence of whose attacks the tubers are unripe, and in a bad condition for preservation.[31] Under

[30] See Ann. des Sci. Nat., vol. 8, p. 257; vol. 9, p.l, &c. Dr. Montagne has made the spores sprout between two plates of glass.

[31] Some persons were inclined to attribute the premature decay, as said above, to frost; but, as the Abbé Michot remarks, "Balsams, dahlias, and other plants susceptible of cold did not suffer."—Rev. Bot., 1845, p. 156.

these circumstances, if decay takes place, there cannot be much matter of surprise; and that, as in all cases of decay, various species of fungi should establish themselves upon the tubers and accelerate it. It is well known, without having recourse to the curious observations of Dr. Nägeli,[32] that various fungi do exist in the tissues of plants, accelerating their decomposition. A very singular species will be described at the end of this memoir. Facts of this kind, whether we observe them or not, are daily before our eyes, and there would be little difficulty in admitting that the decay of the tubers was produced by natural decomposition arising from their imperfect organization, the tubers being unhealthy from various outward circumstances and from the premature decay of the haulm, but for the curious fact that the same mould which springs from the substance of the leaves, uniformly bursts forth from the tubers exactly at the very spots where the decay originates. That the mould proceeds from within I can assert from personal observation, and believe it to be a fact that it could not establish itself on a decayed substance; nor, indeed, have my experiments been successful as regards sound tubers. Portions of the mould transferred to healthy tubers placed in favourable situations for its growth have remained precisely in the same condition, without establishing themselves in their new situation, and inoculation has not at present been attended with any positive result. It should seem certain, then, that the mycelium or elements of the fungus must have pre-existed in the tuber; and as it uniformly springs from the decayed spots, that it has itself caused the decay.

But here a difficulty arises from the great obscurity, or as some say, the total absence of mycelium in an early stage of the disease. I have satisfied myself however of its existence in some cases, but not uniformly. Another difficulty arises from the fact that diseased tubers are found occasionally on plants whose foliage is untouched,[33] or only slightly affected by the mould. The disease in this case at least does not arise from the deterioration of the tuber from the decay of the foliage. But if, previous to the breaking out of the mould from the leaf, the cellular tissue is impregnated with mycelium, a fact which I have had no opportunity of ascertaining since my observations were commenced, it is possible enough that it may be present in the tubers which are leafless branches, and if so, it may exercise its influence on the tuber before it bursts forth from the leaf. And if

[32] Linnaea, vol. 16, p. 237.

[33] Decaisne, Rev. Bot., 1845, p. 150.

these observations be well grounded, the case is merely an exceptional one. In those cases in which I have myself found diseased tubers while the foliage was still more or less perfect, they have always been superficial and partially greened by exposure to light.

The disease, however, is in general subsequent to the decay of the haulm. Now, even granting that no visible mycelium is present in the decayed spots when first exhibited, I cannot grant, taking the ascertained facts into account, that they are independent of the fungi. For without having recourse to the notion of the juices of the plant in general being vitiated by the fungi on the leaves which, indeed, is not consistent with the case just mentioned as brought forward by Decaisne, and if it were, leads at once to the question of the production of the fungus from diseased matter without pre-existant germs, it seems to me most certain, from observation of those fungi which grow from the tissues of plants, that minute particles, too small to be distinguished by the highest powers of the microscope, must be carried about with the juices, and when fitting circumstances concur, proceed to act upon the tissue with which they are in contact.[34] That under certain circumstances foreign particles should produce disturbance of the system is not more surprising than that a moment's breathing an infected atmosphere or the least particle of virus taken up by the absorbents in the human frame should produce such extensive mischief, while in other cases constant exposure to the malaria and more thorough inoculation prove absolutely harmless. That the mould in the tubers should commence by producing decay, contrary to its persumed habits in the foliage, is not so curious as that under such anomalous circumstances the mould should be produced at all. I can see, on mature reflection and consideration of all the difficulties of the case as far as they occur to me, nothing at all absurd in Dr. Morren's views, in which if there be difficulties not solvable at present, there are at least as great difficulties on the other side.

A somewhat analogous decay is now attacking Swedish turnips, commencing in little sinuous lines, which follow the course of the

[34] It is well known that bunt is communicable by rubbing sound grain with the spores of the fungus. It does not seem to have been ascertained at present how the spores act: whether they vegetate on the surface, and send their mycelium into the tissue of the young plant, or whether the contents of the spores are imbibed. The usual mode of germination in fungi is a protrusion of the membrane of the spore; but it is very probable that the minute contents of the spore or its protruded shoot, when absorbed and circulating with the juices, would produce the perfect fungus under favourable circumstances. The spores themselves could not enter the stomata.

scalariform vessels, around which dark granules are deposited somewhat after the fashion of those in the potato cells. It is curious that in extensive fields the foliage is to a very great extent destroyed by *Botrytis* [*Peronospora*] *parasitica,* a nearly allied species.

The fact that the earliest potatoes, which had cold and wet weather enough to contend against, were not attacked, is much in favour of the fungal theory, the foliage never having suffered. The second crops suffered perhaps nearly as much as the later—in some cases more so.

The circumstance of the concentric arrangement of the spots in certain cases appears to me of great importance, as indicating their origin from a fungus. I regret much having searched in vain for fresh specimens of *Oidium fructigenum,* the species of which Ehrenberg made his observations on the growth of fungi, with a view to ascertain the condition of the mycelium. As the texture of the matrix, however, is so loose, it would be probable that it would be freely developed, as is the case with that which is so abundant in the ordinary decayed spots of pears and apples.

The reports are so contradictory as regards the subject of contagion, that it is impossible to build anything upon them.[35] Some deny the fact altogether, while others say that a single diseased tuber is sufficient to infect a thousand. When it is considered that apparently sound tubers will, even though exposed to light and kept dry, in a few days exhibit the disease, and that in a moist place the change takes place more certainly, be the selection as careful as it may, it appears clear that no experiment of sprinkling them with the water in which diseased individuals have been boiled, or confining them within the same atmosphere, or even of placing apparently sound individuals in contact with unsound, can be conclusive. I have seen no evidences of contagion in the experiments I have myself instituted.

Were a single fungus only produced upon the tubers, viz., that which grows upon the leaves, there would be less difficulty, I believe, in admitting the agency of the Botrytis. The difficulty is, I think, however, overrated: when it is considered how extensively—nay, universally—moulds are produced in decaying matter, and how many species occur upon one putrescent mass, it will not seem so wonderful that when the Botrytis has superinduced decay, other species should follow in its wake. If the peculiar spots, in the first instance, were found on extensive trial to produce indifferently a variety of species, the case would be different, but if, as I believe, the Botrytis always

[35] Payen thinks it not contagious: Morren, on the contrary, contagious.

precedes when the trial is sufficiently early, the conclusion is evident.

Before closing this part of my subject it may be well to mention an observation which I made during the course of my investigation. On examining the cuticular cells of a young tuber, with a view to ascertain the changes which occur in the process of greening, I found evident traces of mycelium within them. Little attention was paid to the circumstance at the time, though I made a sketch of the appearance, which will be found amongst the figures. The potato was then exposed to the light and sun in the window of my study, the weather being dry, when, to my great surprise, in a few days it exhibited the spots peculiar to the disease, and was, in a few days more, completely decayed. I am not at all certain that the mycelium was connected with the spots, but the circumstance seems worth recording.

The disease, if it be due to any specific cause, which I think is clear, however obscure that cause may be, can scarcely be expected, after having had so extensive a range, to subside all at once. The same atmospheric conditions which have favoured its progress are not likely to occur again; but still I fear that it will be felt directly or indirectly for some time, as in the human frame the general prevalence of a particular disease modifies other diseases for many successive seasons. Such, I am assured by one of the most intelligent practitioners in England, and than whom no one has paid more attention to the particular disease or been more successful in its treatment, has been the effect of cholera in a large town where it was extremely prevalent. Diseases appear under a new type and require a different treatment. A diseased stock can scarcely be expected to produce a perfectly healthy offspring.

On the supposition that it springs from some contagious matter, we can form no probable conjecture, execpt by mere analogy; but if it arises from a parasitic fungus, it may be hoped from our experience of other productions belonging to the same tribe, that succeeding conditions of the atmosphere may be more or less unfavourable to its development, for it is most certain that the germs of cryptogamic plants may be present in tissues and yet remain more or less inert, unless peculiar circumstances should concur—exactly as the seeds of phænogamous plants may lie dormant in the earth for centuries.

The Irish Commissioners have wisely taken a wide view of the subject in their reports, and in a case of such difficulty it is seldom safe to trust entirely to one's own particular views. The safest and the best plan on every account is to keep our minds in a condition

to meet the subject, should it unhappily obtrude itself again upon the attention of the public, without prejudice, and we shall then have some prospect of discovering the proper remedies.

I come now to the more purely botanical part of the question, namely, the description of the parasite which has been so constant an attendant on the disease. And here, as if no part of the matter were to be free from debate, a little difficulty presents itself in the outset as regards the name. The mould has been severally named by Monsieur Desmazières, Dr. Montagne, and Mlle. Libert. There is no question, I think, as regards the first; but Dr. Morren, in a paper published in the Transactions of the Royal Society of Gand,[36] claims reason which induced him so to do, was that in Dr. Morren's Memoir, in the Belgian Indépendance of the 18th of August, no specific name was assigned. It appears indeed from M. Duchartre's Memoir,[38] the priority for Mlle. Libert. Unfortunately he does not state in what work that excellent mycologist had characterised the species previously to the public notice made by Dr. Montagne before the Société Philomathique of Paris, on the 30th[37] of August. The very that Mlle. Libert was the first to publish the opinion of Dr. Van Oye, in L'Organe de Flandres; but whether the species is there characterised or not I am unable to say. But even supposing such to be the case, it can scarcely be deemed a publication within the meaning of the botanical canons, which demand some medium of publication generally accessible, which a political journal not likely to be preserved in public libraries can scarcely be accounted. I feel therefore upon the whole bound to adopt the name assigned by the great French cryptogamist. The following characters were transmitted to me by him, together with copious sketches of this and other species which I have availed myself of in the figures. It was his intention to have published them himself, but at my request he gave up the intention, placing his materials in my hands—a mark of kindness and liberality which demands public thanks, though only one amongst a multitude of similar instances.

The species is characterised as follows:—

Botrytis infestans Mont. [now *Phytophthora infestans* (Mont.) de Bary] cœspitibus laxis erectis albis apice plus minus ramosis; ramis passim nodosis erecto-patentibus, sporis lateralibus terminalibusque

[36] Ann. de la Soc. Roy. d'Agriculture et de Botanique de Gand, 1844, p. 290.

[37] Dr. Montagne had several days previously communicated it to me with a complete analysis, under the same name.

[38] Rev. Bot. 1845, p. 151.

solitariis ovoideo-ellipticis pro ratione magnis concoloribus subapiculatis, nucleo granuloso. Mont. L'Institut, 1845, p. 313.—*Botrytis fallax* Desm. MSS.—*Botrytis devastatrix* Lib.—Morren, in Ann. de la Soc. de l'Ag., &c., de Gand, 1845, p. 287, cum Icone.

Hab. in paginâ inferiori foliorum Solani tuberosi necnon in tuberculis ipsis aggeratis.

Maculae albae farinosae parum densae aut confertae in parte folii inferiori observantur. Flocci steriles inter meatus intercellulares repentes, fertiles, qui e stomatibus emittuntur, inter pilos folii sparsi erecti subtus simplices ½ lineam in tuberculis attingentes superantesque, saepius vero praesertim ad folia 2/5 lineam metientes, apice ramosi septati albi. Rami 2 ad 6 erecto patentes acuti virgati passim elliptico-subincrassati hinc nodosi. Sporae pro ratione plantae maximae primò globulosae ovoideae tandem eliipticae et tum seminibus Peponis non absimiles, altero fine ad speciem mammillatae subapiculatae, altero vero brevissime pedicellatae, pellucidae, floccis concolores, nempe niveae, intus sporulis endosporio inclusis farctae. Long. spor. 3/100 millim., crassit. 2/100 millim.

The peculiar characters of the species consist in the few erecto-patent not forcipated or uncinated branches; the scattered spores, and above all the torulose swellings which give it somewhat the appearance of Gonatobotrys. The spores however are not disposed round the knots as in that genus and Arthrobotrys, or even confined to them. The only species which exhibits anything of the kind is one which has been named *Botrytis Urticae* by Mlle. Libert and which indeed M. Desmazières considered as identical. It appears to me however that it is quite distinct, the flocci being far more divided, the apices bifid, and the colour, instead of white, a greyish lilac. I have had the opportunity, fortunately, of comparing specimens, which occurred in the autumn, at Tansor, in Northamptonshire, with authentic individuals from M. Desmazières. Various allied species occur in similar habitats characterised by their large spores. These, though closely allied to each other, differ in their mode of ramification and in the form and size of their spores. The best known of these is *Botrytis* [*Peronospora*] *parasitica,* which occurs on Cruciferae. Of this, as occurring on the leaves of cabbages and Swedish turnips, I add a figure, as also brief characters and figures of four undescribed species, for the sake of comparison with *Botrytis infestans.*

Botrytis *Arenariae* n. s. [now *Peronospora Arenariae* (Berk.) de Bary] nivea; floccis fertilibus sparsis superne dichotomis, apicibus divaricato-furcatis non uncinatis; sporis ovatis terminalibus.

Hab. in paginâ inferiori foliorum Arenariae trinervis. June, King's Cliffe.

Botrytis *Viciae* n.s. [now *Peronospora Viciae* (Berk.) Casp.] nivea; floccis fertilibus elongatis sparsis parcè ramosis; ramulis bifidis non uncinatis; sporis obovatis apiculatis terminalibus.

Hab. in paginâ inferiori foliorum Viciae sativae. June, King's Cliffe. A distinct species, forming definite purplish patches, occurs on Peas.

Botrytis *arborescens* n. s. [now *Peronospora arborescens* (Berk.) de Bary] nivea; floccis fertilibus superne ramosissimis di-trichotomis; apicibus subforcipatis; sporis terminalibus minoribus subglobosis.

Hab. in paginâ inferiori Papaveris Rhoeas, quod omnino destruit. June, King's Cliffe.

The plants are attacked when quite young, and have a peculiar aspect by which they may be known at a distance.

Botrytis *ganglioniformis* n. s. [now a synonym of *Bremia Lacteae* Regel] nivea; soris definitis; floccis fertilibus superne ramosis, ramulis curvatis sub apicibus dilatatis ganglioniformibus; sporis minoribus terminalibus subglobosis. B. parasitica var. Lactucae, Berk Brit. Fung., No. 331.

Hab. in paginâ inferiore Lactucarum in hortis. May, King's Cliffe.

Many other undescribed species occur, related to *Bot. effusa* Grev. [*Peronospora effusa* (Grev. ex Desm.) Rabenh.], but differing in various characters. All exercise a greater or less influence on the health of the plant attacked. Dr. Morren informs us that beet-root has suffered from a species during the present autumn, and also pear-trees.

No good figure has yet appeared of *Botrytis Bassiana,* which attacks silkworms: I have therefore availed myself of a sketch kindly communicated by Dr. Montagne [see Fig. 32]. It will be seen that it is extremely like *Botrytis diffusa* Alb. and Schwein; but this is, I believe, more in appearance than reality, for perfect specimens of that species exhibit a very complicated structure, each head consisting of numerous lobes, each of which bears a number of spores attached to little spicules—a structure quite different from that of Botrytis.

I have also figured the little mould alluded to above as once occurring on a tuber which had long been diseased instead of *Botrytis infestans.* It has all the characters of Dactylium, in consequence of which I had named it in my herbarium *Dactylium tenuissimum*: I have, however, since the figure was sent to the engraver, seen young

plants of *Fusarium Solani Tuberosi* Desm., which resemble it so closely that I am inclined to think it merely a more persistent state than usual of that species.

Amongst the diseases noticed by Martius is one which he considers as depending on a species of Protomyces. As I have seen this in various stages of growth and attached to its flocci, I have thought it worth figuring [see Fig. 30]. It appears to me to belong to the genus Tuburcinia Fr. The spores have usually one or more cavities in the surface communicating with the interior cavity. They may perhaps therefore be considered rather as compound bodies consisting of a quantity of cells arranged in the form of a hollow ball. This view of their structure requires more attention than I am able to give to it at present.

I shall end the memoir by giving the characters, after Dr. Montagne, of a highly curious fungus discovered by Dr. Rayer, chief Physician of the Hôpital de la Charité, at Paris, during the course of a series of observations on potatoes. It is produced and fructifies in the intercellular passages of germinating potatoes.

ARTOTROGUS MONT.

Flocci continui ramosi flexuosi per meatus intercellulares vagantes serpentesque. Sporae terminales vel (ob prolificationem?) medio filo insertae, primo laeves, sphaericae, rufae, intus farctae, tandem solutae, liberae, echinulatae. Locus in systemate inter Sepedonium et Tuburciniam prope Asterophoram.

Artotrogus hydnosporus Mont.—Gard. Chron., 1845, p. 640.

Hab. inter meatus cellulares tuberculi Solani tuberosi, germinatione absolutâ.

King's Cliffe, Nov. 22, 1845.

Fig. 1. Potato in an early stage of the disease.

2. Section of one in which the disease is more advanced.

3. Small ash-leaved potato, showing a concentric arrangement of the spots. In larger tubers there are sometimes two systems of concentric spots.

4. Vertical section of a small red potato, in which the portion to the left has become green externally; showing the external cells and a few of the internal feculiferous cells (a), some of which at (b) are attacked by the disease, and, in

consequence, have their walls clouded with brown specks. The cells immediately beneath the cuticle do not contain fecula, though they sometimes seem to do so under the microscope from stray granules having been introduced accidentally. Four of the lower cells exhibit *Botrytis infestans* just commencing. The grains of fecula in the diseased cells are, in this stage of the disease, not diminished in number, but some have escaped in consequence of the division of the cells. In the external cells the cytoblasts are visible at (d), which in the green portion (c) are greatly enlarged, and furnished with radiating processes.

4*. Appearance presented by healthy and diseased cells when boiled.

5. Horizontal section of diseased cells (by Dr. Montagne) magnified 380 diam. The lines on the grains of fecula are omitted, to simplify the figure.

6. Horizontal section from surface of an apparently sound potato, showing abundant mucedinous threads. This potato, when exposed to the sun with a view to observing the changes which take place in the contents of the cells during the process of greening, became in a few days highly diseased.

7. Section of one of the dark patches on the stem which occur in the course of the disease. There is no trace of mucedinous filaments, but the cells are filled with a dark grumous mass.

8. Horizontal section of another patch exhibiting several mucedinous threads.

9. Section of potato-leaf, showing the hyphasma of *Botrytis infestans* Mont., creeping amongst the loose tissue of the underside, and sending up fertile shoots through the stomate. The mould is still young, one shoot not having at present formed any branches or fruit. The tissue of the upper surface of the leaf is too compact to allow the threads of the mould to traverse it.

10. A portion of the cuticle of the lower surface, showing the threads of the Botrytis proceeding from the stomates. The mould, with the exception of the plant at the left hand, is scarcely more advanced than in the preceding figure.

11. Portion of cuticle of the lower surface more highly magnified, showing three forms of stomates, from one of which proceeds a young plant of *Botrytis infestans.*

12. View of a horizontal slice of the cuticle of the lower surface of a leaf viewed from within, and showing the disposition of the stomates in the reticulations formed by the loose tissue.

12*. Full-grown *Botrytis infestans,* from leaf, partly from a sketch by Dr. Montagne.

13. Dwarf form from stem, sent from Bristol by C. E. Broome, Esq.

14. Full-grown plant from tubers, partly from a sketch by Dr. Montagne.

15. Base of two filaments, 780 diam., from sketch by Dr. Montagne. This is not the normal structure, but merely a curious form assumed by certain filaments accidentally detached from the hyphasma.

16. Extremity of branch, with two swellings. 380 diam.

17. Occasional appearance of spore. 380 diam.

18. Spores with their contents. mag. 380 diam.

19. Spores, 780 diam. This and the four preceding figures are from sketches kindly sent by Dr. Montagne.

20. *Dactylium tenuissimum* Berk.

21. Spores of ditto.

22. *Botrytis Arenariae* Berk.

23. *Botrytis Viciae* Berk.

24. *Botrytis arborescens* Berk.

25. *Botrytis ganglioniformis* Berk.

26. *Botrytis parasitica* Pers.

27. *Artotrogus Hydnosporus* Mont.

28. Thread of ditto, mag. 780 diam.

29. Mature spore of ditto, 380 diam. This and the two foregoing figures are by Dr. Montagne.

30. *Tubercinia scabies* Berk. [now a synonym of *Spongospora subterranea* (Wallr.) Lagerh.]

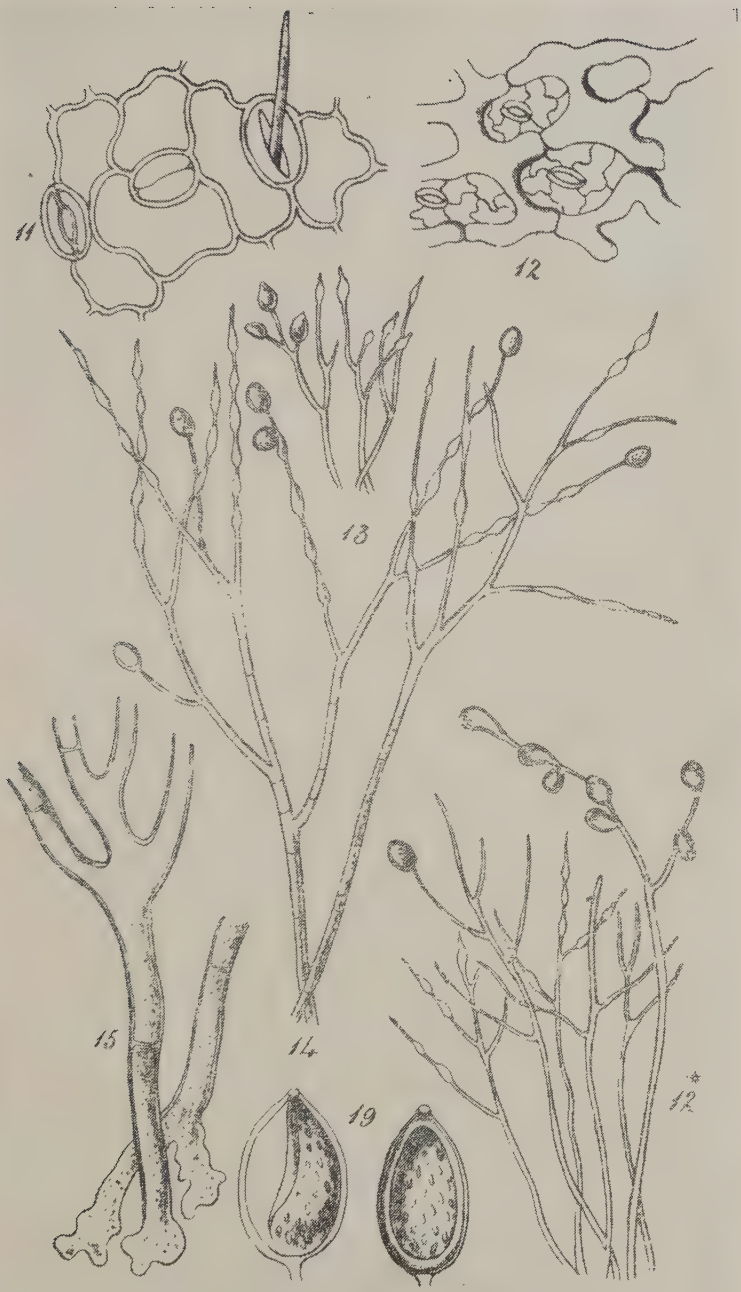
31. Cells from surface of ditto.

32. [Fig. A] *Botrytis Bassiana,* from a sketch by Dr. Montagne. *a.* Young thread. *b.* Thread more advanced, with young spores. *c.* Ditto full grown, with mature spores.

The Potato disease

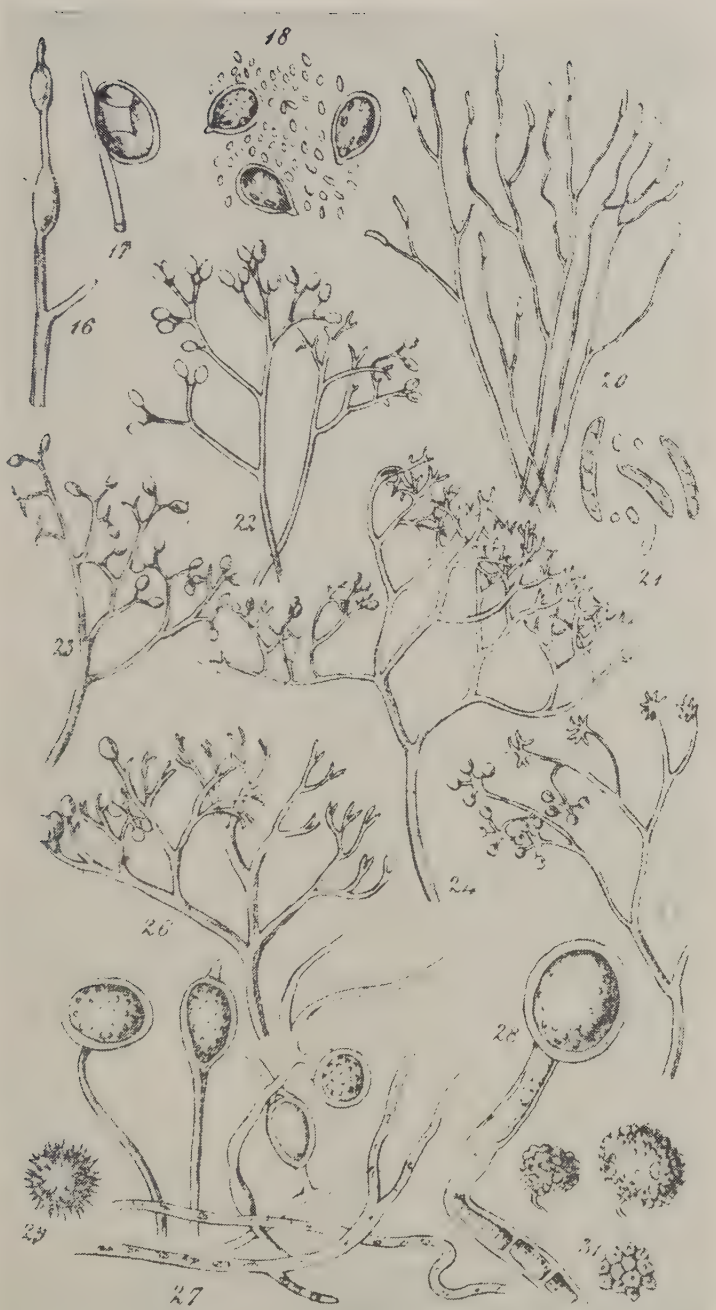
Reeve Brothers, imp.

The Potato disease.



Reeve Brothers, imp.

The Potato disease.



Reeve Brothers.

The Potato disease

Fig. A.

Vegetable Pathology

by

M. J. B.

[Vegetable Pathology appeared as a series of 173 articles in the *Gardeners' Chronicle and Agricultural Gazette* between 7 January 1854 and 3 October 1857. The last article included 'a synopsis of the contents . . . and a classified arrangement of the maladies described with reference at once to the numbers of the several paragraphs and the page and volume of the Journal in which they are contained'. This synopsis is here placed first and the numbers of the paragraphs reprinted in the selection which follows are in bold face arabic numerals.]

Synopsis

The divisions under which the subject is proposed to be treated, preceded by a few brief remarks, form the contents of the first number, 1854, p.4.

¶ 1. (1854, p. 20.) HISTORICAL, No. II[1]. Containing a short notice of the works upon the subject which had previously appeared.

2. (1854, p. 36.) GENERAL REMARKS, No. III.
Work confined almost exclusively to the diseases which affect objects of cultivation in the garden and farm.
Science in a state of infancy.

[1] These roman numerals refer to the numbers of the articles.

Comparison of its difficulties with those which attend animal pathology.

Results which may reasonably be expected.

3. (1854, p. 52). USES OF THE SCIENCE, No. IV.

Prevention often more important than cure.

Connection with the true theory of horticulture.

Evil effects of bad cultivation.

Good effects of scientific culture, as illustrated by the treatment of the Grape mildew at Margate, on its first appearance.

Cholera studied scientifically, and with much practical benefit at the same place.

Inference as regards the use of deep study of Vegetable Pathology.

I. PLANTS IN A STATE OF HEALTH.—(Nos. V. to XLIII.)

[For the scope of this section (Paragraphs 4-194), see the introductory article (Article No. I) reprinted below.]

II. WHAT IS DISEASE, WITHIN THE MEANING OF THE TERM, AS USED BY CULTIVATORS.—(Nos. XLIV-XLV.)

195. (1854, p. 708.) Not of the same latitude as when used in animal pathology.

196. Objects of cultivation often abnormal.

197. Peculiar secretions generally diminished in objects of cultivation.

198. (1854, p. 724.) Often in a really diseased condition though answering the ends of the cultivator.

199. Case as regards fruit.

200. Bletting, though essentially a diseased condition, sometimes a necessary end.

201. Case as regards flowers.

202. Conclusion as to what is disease in the sense of the cultivator.

III. CAUSES OF DISEASE.

a. Internal or Constitutional.—(Nos. XLVI-XLVIII.)

203. (1854, p. 740.) Constitutional defects of individual plants.
204. Such defects hereditary. Notion of wearing out controverted.
205. Notion of the same as regards fruit trees.
206. Propagation from diseased individuals may lead to erroneous notions respecting the qualities of a species or variety.
207. (1854, p. 756.) Disease may permanently affect a constitution hitherto healthy.
208. Sterility may be constitutional.
209. Chlorosis.
210. Hypertrophy.
211. Many valuable garden plants result of debility.
212. Good varieties of flowers come from the weakest looking seeds.
213. (1854, p. 772.) Hybrids.
214. Permanence of some varieties and variations.
215. If objects of cultivation are often essentially in a diseased condition, cutivators ought to expect impediments arising from such a condition.
216. Difficulty of healing in diseased plants.
217. Fungi may aid decay, when not original causes of it.
218. The effects of unfavourable external conditions not to be ascribed to constitutional weakness.

b. External or Accidental.—(Nos. XLIX-L.)

219. (1854, p. 788.) Constitutional disease may in the first place arise from external causes. Their immediate effects.
220. Specific external agents.
221. Ravages of insects and other animals.
222. (1854, p. 804.) Galls.
223. Ravages of vegetable parasites.
224. Real and false parasites.
225. Fungi fructifying within closed cells.
226. Fungi propagated at first within the plant.
227. White and black mildew.
228. Larger Fungi, Lichens and Mosses.

c. Doubtful or Conjectural.—(No. LI.)

229. (1854, p. 820.) Substitution of words for facts.
230. Equivocal generation.

IV. CLASSIFICATION OF DISEASE.—(Nos. LII-CLXX.)

231. (1854, p. 836.) Diseases constitutional or accidental.
232. Functions of plants. Circulation and respiration.
233. Nervous energy.
234. Functions obscure, and consequently their derangements.
235. Difficulty of classifying according to such derangements.

a. INTERNAL OR CONSTITUTIONAL.

**Functional.*

236. (1855, p. 4). All disease productive of organic change, though not always appreciable.
237. Functional malady induces organic change.
238. Effects of functional disease on vital force.
239. Consideration of specific diseases.
239 bis. (1855, p. 20.) Similar diseases may arise from different causes. Difficulty therefore of arranging them under distinct heads.[2]

Genus I. STERILITAS. *Unproductiveness* (240).

1. Constitutional and functional (241-244).
2. Constitutional and organic (245-250, 1855, p. 36).
3. Accidental and functional (251-257, 1855, p. 52).
4. Accidental and organic (258-263, 1855, p. 68).

Gen. II. APOSTAXIS. Distillation or abnormal emission of nutritive or secretive fluids (264, 1855, p. 84).

1. Weeping. Overflowing of sap (265-266, 1855, p. 84).
2. Bleeding. Discharge of sap by means of ruptured organs (267, 1855, p. 100).
3. Gumming. Discharge of gum (268-271, 1855, p. 116). Tragacanth (271*, 1855, p. 204). (271**, 1857, p. 400).
4. Resinous discharge (272-275, 1855, p. 133). (272*, 1857, p. 484[3]).
5. Honey Dew. Discharge of sugary matter (276-281, 1855, p. 152).
6. Discharge of manna (282-285, 1855, p. 172).
7. Discharge of starch (286-287, 1855, p. 188).

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[2] The arrangement of diseases into *sthenic* and *asthenic,* though at first plausible, is in practice as full of difficulty as that which is here adopted.

[3] This might be placed in *Carcinodes,* as a case of that genus complicated by discharge of resin.

Gen. III. VARIEGATIO. Normal defect or modification of Chlorophyll (289-295, 1855, p. 220).

Gen. IV. DECOLORATIO. Normal change of colour (236-298, p. 240).

Gen. V. CHLOROSIS. Abnormal defect or modification of Chlorophyll (299-302, 1855, p. 260).

1. Chlorosis of Cacti (303-304, 1855, p. 278).
2. Chlorosis of Hyacinths, 305.
3. Chlorosis of Onions (305*, 1855, p. 421).
4. Chlorosis of Cucumbers. *Cucumber disease* (306-309, 1855, p. 301).
5. Chlorosis of Clover (308*, 1857, p. 436).
6. Chlorosis of Orchids (309*, 1855, p. 316).
7. Potato Curl (310-313, 1855, p. 334).
8. Dry Rot in Potatoes, 314-315.

Subgenus *Icterus*. Yellowness.

1. In Wheat (316-317, 1855, p. 356).
2. In Vines (318, 319, 1855, p. 372).
3. Produced by Fungi, 320.
4. Produced by Insects, 321.

Gen. VI. PRÆCOCITAS. Forwardness (322-324, 1855, p. 388).

Gen. VII. SENECTUS. Old age (325-327, 1855, p. 404).

** *Organic* (328-330, 1855, p. 436.)

Gen. VIII. PERIANTHOMANIA.[4] Abnormal multiplication of Bractes, sepals, &c. (331-333, 1855, p. 452).

Gen. IX. PETALOMANIA. Multiplication of Petals (334-336, 1855, p. 468).

Gen. X. ANTHEROMANIA. Multiplication of Anthers (337).

Gen. XI. CAPSOMANIA. Multiplication of Pistils, &c. (339-342, 1855, p. 486).

Green-centred Roses, &c. (343-348, 1855, p. 516).

Bladder Plums (349-352, 1855, p. 532).

Gen. XII. CARPOMANIA. Grittiness of fruit (353, 1855, p. 549).

Gen. XIII. PHYLLOPTOSIS. Fall of leaf.

Gen. XIV. CARPOPTOSIS. Fall of fruit.

Shedding of Rice[5] (352*, 1856, p. 36).

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[4] Ré's arrangement [Saggio teorico-practico sulle malattie delle piante by Filippo Ré, 2nd Edition, Milan 1817; English translation *Gdnrs' Chron.*, 1849, p. 211, 228, et seq. to 1850, p. 469.] has been followed here, but it would be better to consider this and the following analogous instances as species of one common genus.

[5] This when better known will probably be referrible to a distinct genus.

Gen. XV. ANTHOPTOSIS. Fall of flowers (354, 355, 1855, p. 564);[6] (356-359, 1855, p. 580).

Gen. XVI. CLADOPTOSIS. Fall of branches (360-363, 1855, p. 596).

Gen. XVII. CARCINODES. Canker. Constitutional decay attended by distortion or the development of unsightly excrescences or depressions (364, 365, 1855, p. 614).

1. Apple canker (366-368, 1855, p. 644).
2. Plum canker (369). See Gumming.
3. Ash canker (370-371, 1855, p. 661).
4. Cherry canker (371*, 1857, p. 453).

Gen. XVIII. CARIES. Decay. Decomposition of cell walls (372, 1855, p. 676; 473, p. 692; 374, 375, p. 709; 375*, 1857, p. 566).

Gen. XIX. HYPERTROPHIA. Excessive development (376-378, 1855, p. 725; 378*, 1857, p. 500; 378**, 1857, p. 517). Clubbing (378***, 1857, p. 597).

Gen. XX. EXOSTOSIS. Hard excrescences consisting of sound tissue.

1. Knaurs (379-382, 1855, p. 756; 382**, 1857, p. 549).
2. Cypress knees (382*, 1857, p. 549).
3. Warts (383-387, 1855, p. 772).

Gen. XXI. SCLEROGENIA. Induration of roots, tubers, &c., without decomposition (388-393, 1855, p. 788).

Gen. XXII. DACTYLORHIZA. Forking of roots (394-397, 1855, p. 804).

Gen. XXIII. SPHRIGOSIS. Rankness (398-399, 1855, p. 820; 400-403, 1855, p. 836).

Gen. XXIV. CŒNOCLADIA. Natural grafting (404-407, 1855, p. 852).

Gen. XXV. ACAULOSIA. Defect of stem (408-413, 1856, p. 5).

Gen. XXVI. HYPOSATHRIA. Bletting. Decomposition of cellular tissue of fruit accompanied by formation of sugar (414-416, 1856, p. 21).

b. EXTERNAL OR ACCIDENTAL.

Functional (411, 1856, p. 36).

Gen. XXVII. DESICCATIO. Sunstroke. Withering (412*-414, 1856, p. 53).

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[6] These three genera may conveniently be comprised in one.

Gen. XXVIII. CONGELATIO. Freezing (415*-418, 1856, p. 69).
Gen. XXIX. VENEFICIUM. Poisoning (419-422, 1856, p. 85; 423-429, 1856, p. 100).
Gen. XXX. ASPHYXIA. Suffocation (430-436, 1856, p. 117).
Gen. XXXI. ANASARCA. Dropsy (437-442, 1856, p. 133).
Gen. XXXII. LETHARGIA. Deferred vegetation (442-447, 1856, p. 153).
Gen. XXXIII. LANGUOR. Premature old age; decrepitude (448-451, 1856, p. 173).
Gen. XXXIV. ALBEFACTIO. Blanching (452-457, 1856, p. 193; 457*, 1857, p. 566).
**Organic* (458, 1856, p. 212).
Gen. XXXV. BRONTESIS. Electric stroke (459-462, 1856, p. 228).
Gen. XXXVI. ANEMOSIS. Windshake (463-466, 1856, p. 245).
Gen. XXXVII. HELIOSIS. Sunburn (467-470, 1856, p. 261).
Compare *Desiccatio,* which belongs to the functional series.
Gen. XXXVIII. PHILLILESIA. Leaf curl. Blister (471-474, 1856, p. 280).
Gen. XXXIX. CLADODYSTROPHIA. Perishing of branches (475, 476, 1856, p. 301).
Gen. XL. HEMIDYSTROPHIA. Partial nourishment (477-480, 1856, p. 320).
Gen. XLI. VULNERA. Wounds (481-485, 1856, p. 340).
1. Fractures, bruises, &c. (484*-486, 1856, p. 357).
2. Wounds from animals (487-489).
3. Wounds from fire or natural decay (490, 491, 1856, p. 373).

Gen. XLII. PARASITÆ. Parasites (492-496, 1856, p. 388).
1. Phaenogams, *True Parasites. *a.* Dodder (497-502, 1856, p. 405). *b.* Broomrape, Mistletoe, Balanophorae, &c. (503, 504, 1856, p. 421).
**False Parasites. Ivy (505-508, 1856, p. 436).
2. Cryptogams (509-515, 1856, p. 452).
*Fungi. *a. Ascomyces* (516-519, 1856, p. 470).
b. Erysiphe (520-527, 1856, p. 485).
Hop and Grape mildew (528-534, 1856, p. 501).
c. Cyttaria (536, 1856, p. 517).
d. Rhytisma (537).
e. Dothidea (538, 539).
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g. Capnodium (including *Antennaria*) (548-554, 1856, p. 564).

h. *Botrytis* (555-558, 1856, p. 580).
(559-564, 1856, p. 596). Potato murrain.

i. *Stemphylium,* &c. (565-568, 1856, p. 612).

j. *Helminthosporium, Cladosporium* (568*-571, 1856, p. 629).

k. *Polyactis* (572-574, 1856, p. 644).

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m. *Peridermium,* &c. (578*-581, 1856, p. 693).

n. *Tubercinia* (582-585, 1856, p. 708).

o. *Ustilago.* Smut (587-593, 1856, p. 725).

p. *Tilletia.* Bunt (594-598, 1856, p. 757).

q. *Uredo,* &c, Rust (599-602, 1856, p. 788).

r. *Gymnosporangium* (603-605, 1856, p. 804).

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REMEDIES OF DISEASE.—(Nos. CLXXI-CLXXII.)

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669. Division into certain and uncertain, and first, certain and rational.

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672. Doubtful and empirical.

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A variety of circumstances, but more especially the severe and widely extended maladies which have of late years affected some of the more important objects of cultivation, have concurred since the commencement of this Journal to call the particular attention both of scientific and practical men to the diseases which affect the vegetable world. Many papers, in consequence, of more or less importance have appeared in our Journal and elsewhere, both in this country and on the Continent, but the process of reference has now become so long and perplexing, and the amount of information so large in point of mere bulk, that it seems desirable to place before our readers, in a compendious and more easily accessible form, all that is well ascertained upon the subject as far as our own experience and access to recorded information may enable us to do so. We propose, therefore, to institute a series of papers after a plan which will be presently stated, comprising everything really valuable, both in theory and practice, which can be supposed at all to come within the scope of an intelligent cultivator, and open to new information from every available source. It is purposed, indeed, to adhere strictly to the plan which has been laid down, in order to avoid as much as possible the confusion which must necessarily attend mere desultory essays or papers; but, inasmuch as the series may possibly be of considerable extent, as important forms of disease may arise, or interesting information respecting those which have been already noticed, a system of numbering will be adopted, by means of which it will be possible to give supplementary matter, at once referable to its proper position in the series, considered as a whole. The method, then, which it is purposed to adopt will be as follows:—

After such introductory matter as may be thought necessary before a more formal commencement of the subject, the subjoined division is proposed:—

I. Plants in a State of Health.

Under this head their nature and structure and mode of nutrition must be briefly stated; the manner in which they are affected by external agents, as light, temperature, moisture, &c.; their more

prominent chemical conditions, and how these are modified by the vital principle or rather in organisms endowed with life.

II. What is Disease within the Meaning of the Term as used in general by Cultivators?

III. The Causes of Disease.
  a. Internal or constitutional.
  b. External or accidental.
  c. Doubtful or conjectural.

IV. Classification of Disease.
  a. Internal or constitutional.
    * Functional.
    ** Organic.
  b. External or accidental.
    * Functional.
    ** Organic.

V. Remedial Measures.
  a. Certain.
    * Rational.
    ** Empirical.
  b. Doubtful.
    * Rational.
    ** Empirical.

General Remarks

2. Before entering on the subject of vegetable pathology, in pursuance of the plan which has been laid down, it may be proper to make a few remarks, either with a view to place it within practicable and useful limits, or to show what may reasonably be expected in the present state of our knowledge.

Now as the main scope of a journal like the *Gardeners' Chronicle* is specific, it would obviously be absurd to enter into any lengthened account of diseases or morbid changes of structure or form in those plants which are not objects of cultivation, except so far as they may throw light on points of more immediate and practical interest. The numerous diseases, for instance, with which Lichens are affected, and the various changes to which they are subject, however interesting in a systematic and physiological point of view, would be wholly out of place here, and would indeed demand a special study for their

due apprehension. On the contrary, any maladies immediately affecting an important crop like that of artificial Mushrooms, or plants such as Ferns and their allies, for which there is a large and extensive sale, would fairly come within our province, and any extraneous matter bearing on those points would very properly demand admittance. A due degree of forbearance will therefore be exercised in such matters, so that nothing may be introduced which has not some palpable relation to the end in view.

It is moreover to be premised that novelty is not the object at which the series will aim. The point if possible to be attained, is to present to our readers, without any necessity of further reference, whatever, within certain prescribed limits, has a direct bearing on diseased action in vegetables. Facts, and not merely ingenious theories unsupported by experiments are what is wanted, and these stated in clear and simple language, so as with an ordinary degree of attention to be perfectly intelligible by themselves. It may not indeed always be possible to speak without hesitation, from the absence of such complete information as may satisfy every requirement, and the more especially because even in points where the difficulties involved may not be deemed insurmountable, recorded observations are either too recent, or so far unsupported by a multitude of evidence, as to justify a reasonable degree of doubt. It must be remembered, besides, that vegetable pathology is comparatively in a state of infancy. The last 10 years indeed have conspired to call the attention of physiologists to morbid structures in vegetables, and the causes from which they are derived, and much light has in consequence been thrown on points which were before involved in obscurity, but still the amount of information which has been obtained is nothing in comparison of what a full development of the subject would demand. If it is recollected how many thousands, urged by every motive of ambition, gain, or a simple love of truth, have been engaged for centuries on the sister science of animal pathology, the immense mass of experience which has been gained, the multitudes of direct observations and experiments which are registered for constant reference, and these sifted and scrutinized so as to eliminate every possible or probable error, and that, after all, the functions of many organs which are obvious to the most superficial examination, are either wholly unknown or very imperfectly understood; and much more when we consider the subject of disease itself, its mode of origination and communication, or even, where the proximate cause is ascertained, its manner of action, it can be no matter of surprise if the vegetable

pathologist is not always in a condition to speak positively, even though it be taken into account that he has less complicated organisms to deal with. And then, again, if the history of disease is contemplated, and we have not far to go for an example, when we find that a malady like that of Asiatic cholera has been ravaging the earth for nearly thirty years, counting its victims by millions, that every practician of any weight or authority has had all his powers of observation and intelligence on the stretch to find a remedy, and that, instead of witnessing any increased power of controlling the disease in individual cases when once established, we have seen it recently even more unmanageable than on any former occasion, it need not be made matter of reproach, as is so frequently the case, against vegetable pathologists, that they can merely describe disease and prate about the causes without discovering any certain remedy. Indeed, the illustration just introduced by way of comparison may be further extended. It is confessed that diseases in the vegetable kingdom when once established are for the most part uncontrollable; they are like consumption or other fatal maladies to which the aid of medicine is called, when nothing more than palliation can be supplied, the prevention of which ascends far higher than to be subject to the control of one generation of physicians, or the influence of a few short years on general habits, on which they are more or less dependent for their origin. But though little may be effected, or be even within the bounds of possibility when once disease has been developed, and though established habits, however fatal in their consequences, are difficult of change, still occasionally, provided there be rational grounds of action, much may be done by way of prevention. The removal of the causes of disease, or perhaps rather of those accidental circumstances which favour or aggravate its development, was attended with complete success in the late prevalence of cholera, although remedies and appliances seemed wholly ineffectual where the disease was once established, and this, be it remembered, in consequence of the powers of mind which had been applied to its investigation by persons of the highest intelligence; and so exactly in the vegetable kingdom, though it may be and is, in many instances, impossible to cure a disease when once contracted—as, for instance, bunt or deep-seated canker—it may be very possible to prevent its occurrence, or to keep them within reasonable bounds. Sometimes, indeed, the cause may be inveterate, and admit of remedy only by a long and painful course, or be so dependent on general habit as to make all hope of immediate or speedy alleviation desperate. Take, for instance,

scrofulous affections or insanity by way of comparison. If proper prudence were exercised in the formation of alliances between families, or habits of a vicious tendency as regards these diseases could be controlled by general opinion, there can be no doubt that either disease would, to a very great extent, disappear; and so again in the vegetable world. It is acknowledged that the objects of cultivation have a greater tendency to disease now than the experience of earlier years would justify us in attributing merely to temporary circumstances; and it is also tolerably clear that this tendency depends on a higher system of manuring, and a want of care in the selection of seed produced under circumstances which might insure health; but then the difficulties in the way of the preparation of such seed in a sufficient quantity to supply the demands of cultivation, and the impossibility of at once controlling any habits or practices generally established, are so insurmountable that the vegetable pathologist must, like the moralist, wrap himself up in his own virtue, and cast his bread upon the waters, assured that it will be found after many days, if not by himself, at least by his fellowmen in some succeeding generation.

Uses of the Science

3. There is, however, beyond doubt, much immediate benefit to be derived from the subject of vegetable pathology. Prevention is at all times more important than the cure of maladies already established, and the person who from mere ignorance would throw doubt on the labour of the vegetable pathologist is the very person who is loudest in his outcries against the theory of horticulture. The two sciences, in fact, go hand in hand, or rather the one is merely an extension of the other. The very principles which form the base of the one are the foundation of the other; and if the aphorisms which appear in our most approved treatise on the true theory of horticulture were verbally reproduced here, excepting as regards such points only as have been illustrated by new observations or experience since its appearance, they would supply a very considerable portion of what is demanded by a series of memoirs like that which we have undertaken. To keep a plant in perfect health, it is not only necessary to know what its healthy condition is, and on what such condition depends, but also to be able to estimate properly what may prevent

or cause disease. And the case is not to be judged by the failures of mere theorists, or by the success which often attends just sense when accompanied by tact, which is in fact but an expression for an intuitive perception of what just theory would suggest, but by a comparison of the results which are obtained where information and practical skill go hand in one. The mere theorist assents at once to the enunciation of some undoubted verity, but applies it ignorantly, and where particular circumstances render it unsuitable; and consequently not only fails of the object in view, but induces diseases by improper treatment. Under such direction, go where you will over an establishment, and, in spite of the most restless activity and earnestness, there is failure everywhere; the Grapes are shanked or mildewed, the Melon-pits unfruitful or full of corruption, the Asparagus wiry, the fruit trees mossy and unproductive, and nothing ready at the time when it is most wanted and expected. And in such cases every remedy which is applied to prevent evil is sure to aggravate it, because it is improperly employed; mere chance, indeed, or empiricism, will often lead to better results, because there is a possibility of their being right, exactly as the mere novice at billiards will make more chance hazards than one who has some particular end in his play, without the necessary skill or science. It is sound knowledge which can alone enable the cultivator to grapple effectually with the difficulties which wait upon him at every turn—which can appreciate important facts when they come before him, and turn them to account. It is sound knowledge, too, which alone possesses the patience which is necessary to the complete investigation of phenomena, in order to their effective control. An apposite instance is afforded by the history of the Grape mildew, which is only second in importance to that fatal murrain which has produced effects on society which could never have been imagined when it first made its appearance. From local circumstances great facilities existed at the spot where the Grape mildew was first observed, for the proper direction of talent in whatever condition of life it might exist. It so happened that a clergyman deeply imbued with the love of natural history and science, though with no pretensions as an author, perceived the good that might be effected in the place by bringing under the control of religion the talent which he perceived existed in no ordinary degree amongst his parishioners. He was seconded in his views by persons of weight and influence either from their position or abilities, and in consequence a most flourishing literary and scientific institution was established, with the greatest desire on every side to promote inquiry even in

persons of the humblest station. One of the fruits of the impression thus made was the production of a statistical account of the place, comprising more especially a review of its sanitary condition, which has obtained a circulation far beyond any local interest, though from the pen of a mere dispenser of the produce of what the Euphuist called "the milky mothers of the herd." It was in this particular locality the Grape mildew first appeared, and as soon as its calamitous nature was ascertained, a gardener in a comparatively small establishment was ready to apply his native talents improved by the local culture just mentioned to the important subject. He began by a microscopical examination, in which he found very ready and competent assistance, and he did not desist from the study till he had discovered an effectual remedy, and in consequence his name, though that of a humble labourer, is now in everyone's mouth wherever the scourge has passed.

What is Disease, within the Meaning of the term as used in general by Cultivators?

195. It is . . . of great importance, before we consider the diseases themselves to which the vegetable world is subject, that we should first have a clear notion what is meant by disease, for the term is not altogether of precisely the same latitude as when used in the science of medicine. In both cases, indeed, some ideal standard is assumed of healthy condition, and every departure from that standard is regarded as morbid; but in either case the normal standard is not the same.

196. The objects of cultivation, except as regards mere botanical species, are seldom in precisely the same conditions as those under which they occur in free nature. The parts which render them worthy of attention, are sometimes the leaves, sometimes the seeds or fruit, sometimes the bulbs or tubers, and sometimes the young stems; and in almost every case, the tendency of cultivation and the main object which the cultivator has in view, is the abnormal increase of those parts, and at the same time a proportional diminution of others less useful, so far, at least, as such a decrease may be consistent with the main end. In many instances the point is to encourage the development of cellular tissue in some particular part; but in most, at the same time, there is a concurrent end, viz., the increase of the peculiar matters, whether starch, sugar, pectine, &c., which the cells are calculated to contain. Sometimes, as in the case of Lettuce, Celery, or

Asparagus, and, indeed, wherever exclusion of light is the proper mean, the efforts of cultivation are in a precisely contrary direction; but more generally, as in culinary roots and tubers and the various kinds of fruit and grain, the point is to increase the nutritive matter as much as possible which the several organs naturally tend to produce, while any peculiar secretions are proportionally diminished. Now it is clear that though these productions of agricultural or horticultural skill are unnatural, they cannot be regarded in the light of disease by the cultivator. To produce these conditions and to improve and increase them as much as possible is the grand point to which his skill is directed, and therefore whatever has a tendency to keep them in check and to reduce them to their natural condition is looked upon as calamitous.

201. Still more must we restrict our definition when we take into consideration the numerous objects which occupy the time and anxiety of the florist. In the field we do not hesitate a moment to consider what are commonly called monstrosities as so many cases of vegetable pathology. If, for instance, we meet with Clover in which sepals, petals, carpels, and ovules are represented by leaves of the normal form and nature, though differing in size, disease is recognised without hesitation; and so in numerous other cases. But the very object of the florist is to produce flowers differing from the normal form, and multiplying the sepals or petals at the expense both of the male and female organs. If the flowers revert at all to their normal state, or if the multiplied organs, instead of assuming the nature of the especial floral envelope on which their beauty may depend, lose their bright colours and return to the natural green of the parts of which they are mere modifications—or if, instead of forming a compact whorl, they are scattered here and there in a spiral direction round the stem, as is the case not unfrequently when the Tulip is planted in over-manured soil, they are at once pronounced diseased; and so they are for the purposes of the cultivator.

202. We must not therefore regard every deviation from the normal condition of species as disease; but, for the purposes of vegetable pathology, the peculiar attributes of each individual variety or variation, and the ends which they are intended to answer, must be taken into consideration: and so long as their distinguishing characteristics are maintained, they are to be considered as healthy; while deviations from these conditions will rightly be considered, as far as they are concerned, of the nature of disease. In all cases where the necessary functions of the species, or other vegetable form, are im-

peded, and vital action is impaired, whether tending to actual decay or to the obstruction of the main ends of cultivation, we must assume that diseased action is going on, and, if possible, we must suggest the proper remedy.

Causes of Disease

Doubtful or Conjectural

229. Though many of the causes of disease in the vegetable world are known, and even the manner of their operation ascertained with tolerable accuracy, it is quite impossible, in so difficult a subject, to obtain satisfaction on every point. There is, however, a concurrent tendency in the human mind to seek a cause for everything, and at the same time to rest contented with mere words, which give no solution of the difficulty, or with assertions which do not rest upon a single fact. How often, for instance, as regards diseases to which man is subject, is every inquiry silenced by such a word as neuralgia, which in reality only expresses the very fact under consideration without any attempt at assigning a cause. And the case is just the same with the diseases of the vegetable world. The mouth of the vulgar is stopped by mere "words without knowledge," while the person who uses them perhaps plumes himself on his superior insight into the secrets of nature. Thus, for example, the diseases which have of late been so prevalent amongst our more valuable objects of cultivation, have been asserted to arise from some unknown cause, distinguished by the name of blight, which, though not derived from a Greek fountain, like the favourite neuralgia, equally evades inquiry by the substitution of a name: or, on the other hand, some conjectural cause has been assigned, like that of electricity, without a single fact to render it probable. It is far better, under such circumstances, to confess our ignorance than to blindfold our own eyes, or those of others, by unmeaning phrases or by unsupported conjecture; because the tendency of such attempts is to discourage experiment or to mislead it.

230. The word blight, with numerous synonyms, was at one time supposed quite sufficient to account for every disease, though perhaps as many distinct causes as there are synonyms might have been at work, and these capable of being ascertained and sometimes remedied by a little close attention and common sense. The fancies of equivocal generation are merely the substitution of conjecture for obser-

vation, with a view to meet difficulties which perhaps may never be entirely cleared up. But the truth is that, after all, we are not the least nearer to the solution of difficulties under such a supposition, for, allowing the truth of the theory, we have still to discover what it is which gives the tissues or their contained fluids the tendency to produce those organisms which pass under the common name of blight or some of its equivalents. If we can ascertain the different conditions under which intestinal parasites exist and are developed, we shall have obtained important information which may lead not only to their suppression when formed, but to their entire prevention; while a conviction that they arise spontaneously will at once prevent the acquisition of such information. It cannot, therefore, be impressed too strongly upon the minds of Vegetable Pathologists, of every degree, to divest themselves of all such vanities, and to track nature herself into her secret recesses. In such a case, supposing even that notions should be prevalent as to the degeneration necessarily due to reproduction from repeated division of an individual stock, or to any other conjectural cause, however untrue or insufficient, they will be supported by well-ascertained facts, and not by mere assertion; and if so light will be elicited illustrative of some point of interest, though possibly not of the particular matter under consideration. Mere theory is too often deceptive, and by itself for the most part deserving of little consideration, whereas the wildest conjectures, if tested experimentally, may lead to the acquisition of useful knowledge. When it is asserted, for instance, that the seasons have changed, that the contents of the atmosphere are altered by the excessive consumption of fuel induced by the use of steam, that the electrical condition of the earth is different, or any other similar fancy, it is clear that as mere assertions they are valueless, but if such conjectures lead to a close examination of the several phenomena, information of the most important nature may possibly be obtained.

Classification of Disease

PARASITAE (Parasites)

492. Scarcely any part of the organised world is free from the attacks of parasites, a provision which is clearly one amongst many ordered by the Creator to maintain that balance amongst living beings, without which a few of the strongest only could preserve their station upon earth. These parasites may be either animal or vegetable, and

each of these two grand classes may be subject to the ravages of beings belonging either to its own or to the other organic order. The whale has different *Cirripedes* burrowing into its flesh, the ox and other ruminants have the larvae of various oestri occupying the intestines, skin, or frontal sinus. Insects have hosts of larvae living at their expense and ultimately exhausting their energies, and the same may be said of multitudes of higher animals, whose muscles, glands, arteries and even the brain itself are at times infested in a like manner, while all have animals of various kinds and affinities living on their surface, or occupying, to a greater or less extent, the digestive cavities. But no less are these animals, high as they may be in the scale of creation, including even man himself, subject to the attacks of vegetables. Minute moulds infest their tissues, producing cutaneous disorders or blocking up the passages of respiration, while in inferior animals they penetrate deeply into their substance, and ultimately convert the whole body on which they prey into a fungoid mass. Nor is a life spent in waters, where fungi in general will not flourish, exempt; even there a curious tribe of plants of doubtful affinity, oscillating as it were between fungi and Algae, take their station upon the integuments, and soon effect the destruction of the animals on which they grow.

493. If we turn to the vegetable world something of the same kind arrests our attention. There are, first, a number of plants which, though at first growing at their own expense, soon take possession of others, throwing out wart-like bodies or spongelets from their stems which suck out the sap from their victim, which is at once appropriated to their own uses. No sooner does this take place than the connection with the earth is entirely dissolved by the decay of the root. Other cases occur of plants called false parasites, as Ivy, Woodbine, Clematis, &c., which resemble these externally, but in which no nutriment is derived from the infested plant, which merely affords a proper support, detaining sufficient vegetable matter about its trunk for the purposes of growth, where such matter is requisite. Sometimes, however, the supplies of nutritious matter are derived from the air or from the moisture, which it contains, in which case the trunk simply serves as a foundation on which the roots may run either to keep the false parasite in its place, or at the same time to act as purveyors of nutriment. In other cases the seeds of the parasite germinate on the matrix, their radicle penetrates through the bark till it reaches the albumen, and is thus able to profit by the

elaborated juice. Such parasites may either be clothed with leaves, or furnished only with colourless scales.

494. These cases are, however, harmless in comparison with those in which the parasite makes its first growth entirely within the substance of the plant, and only makes its appearance externally after it has become deeply incorporated with its tissues. The more or less complete destruction at least of the part on which such parasites are developed is always consequent on their presence, and some of the most important diseases of vegetables depend upon their growth. These belong almost entirely to fungi, which are capable of growing on plants which were in perfect health previous to being attacked. This fact has frequently been denied, but there is not the slightest foundation for the notion that fungi cannot grow on healthy tissues. The presence of the spores may indeed at once produce disease, in consequence of which the fungi when developed may flourish the more vigorously; but if so, the disease is still produced in the first instance by the spores.

495. Amongst fungi there are false parasites as well as amongst Phænogams. It is not every fungus which grows upon a plant which is really parasitic. Where parts are already in a state of decomposition fungi may grow as upon any other putrescent matter, and the neighbouring tissues may decay the sooner in consequence of the presence of the fungi. Such cases are constantly occurring in timber, which it is well known soon runs to decay if fungi are once allowed to establish themselves on an unsound part. Other false parasites also infest the leaves and trunks of trees, as Mosses, Lichens, &c., which derive no nutriment from the matrix; and doubtless when these are very abundant they may be injurious by exclusion of light or air, or the harbouring of noxious insects.

496. As animals have their vegetable parasites, so in turn vegetables are infested by animals. The eggs of insects, for instance, are deposited in the young tissues, the growth of which is diverted from its normal course, and multitudes of excrescences of various forms are generated, which are known under the common name of galls. These are seldom injurious, except where they attack the reproductive organs. Other insects, as Vibrios, live within the tissues themselves, and as parasites are more destructive. Others again are attached to the tender bark under the form of scales, not only exhausting the sap, but dispersing their numerous progeny all over the plant, at the same time inducing the growth of soot-like fungi till the functions dependent on light and aeration are at length fatally impeded,

while myriads of minute insects belonging to the genus Aphis, almost equally inseparable with the scale insects from the mother plant and even more proliferous, suck up the juices from the leaves just as they are elaborated, so that scarcely a drop descends for the formation of wood and the storing up of nutriment for future use in perennial plants, or for the carrying on of the less enduring functions of those to which a shorter existence is allotted.

509. *Cryptogams.* Parasitic Cryptogams have almost the same relation in respect of their parasitism to the plants on which they prey, as Parasitic Phænogams. Like them they are divisible into two principal groups, true and false parasites. The false parasites may, however, in some cases, in consequence of their ultimate effects when once established, be as fatal as those which are more immediately or directly injurious.

510. Before we proceed to the consideration of the more prominent species which are injurious to plants, it is requisite to make a few observations. A very large portion of fungi grow on decayed or decaying animal or vegetable matter. It has therefore been doubted whether it is possible for any fungus to establish itself upon an organism in perfect health. But fungi are not the only parasitic Cryptogams. There are truly parasitic Algae and Lichens as well as fungi. *Elachistea scutulata,* for instance, is so incorporated with *Himanthalia lorea,* the common seaweed known under the name of sea-thongs, that it is impossible to say where the tissue of the one ends and that of the other begins. The parasite moreover bears two kinds of fruit totally different from those of the seaweed on which it grows, so that there can be no more question about the one not being a modification of the other, than there is of the Mistletoe being of an entirely distinct nature from the tree on which it grows. The same may be said of those parasitic Lichens which infest the fruit of many other species. There is the most intimate confluence of the respective tissues with complete difference of essence. In neither case is there any pretense that the parasite was established on a plant already diseased.

511. It is a well known fact that if the spores of *Tilletia caries* (Bunt) are dusted on perfectly clean grains of Wheat, the produce will be diseased. There was, however, no more disease in the Wheat so treated, than in any other grains, till the Bunt was applied, therefore whatever may be the action upon the infested Wheat, it is quite certain that the disease is the consequence of the application of the Bunt spores. In the same way the Grape mildew may be communi-

cated to leaves which are perfectly healthy, both of the Vine and of other plants. The effect may be to set up disease in the tissues wherever the mycelium comes more intimately in contact with them, by means of puckers or otherwise, but the disease is no less the consequence of the fungus, than the silkworm murrain is the consequence of the growth of spores simply dusted on the caterpillar. In the same way disease is produced directly by a host of fungi upon tissues perfectly healthy before they came in contact with the spores of the parasite. It is indeed curious, with such plain and incontestible facts before us, that there should be a disposition anywhere to deny the possibility of moulds growing on perfectly healthy tissue, and consequently of their being the cause of various diseases to which the animal or vegetable world is subject.

512. If, however, there were room for doubt, every pretext for disbelief is done away by the fact that when chemical substances inimical to the growth of fungi are applied, and the mould in consequence dies, the disease of the plant is arrested, though it is plain that if the disease was in the first instance independent of the parasite, its removal could not improve the previous condition.

513. It is to be hoped, indeed, after all that has been published on the effects of fungi, and of the different ways of propagation which exist in the same species, that the fact will now be recognised that fungi are capable of communicating disease. We may in certain cases mistake the real habits of the species. We may attribute disease to the presence of fungi, where the fungi are merely developed on matter already diseased; but with proper pains and a competent knowledge of the species of fungi and their habits we shall not fall into such mistakes. We are not to suppose in every case where fungi are present that they are chargeable with the evil, though they may possibly aggravate it when present. Fruit, for instance, when perfectly ripe, is ready to undergo another series of phenomena which end in complete chemical dissolution. The evil may however be suspended for a time, but the slightest external injury admits the spores of some of our common moulds; they germinate, live at the expense of the cells they traverse, and finally the whole mass is reduced to a putrescent pulp completely overrun with mucedinous matter. In this sense Dr. Hassall is perfectly right that decay is produced by mould, but the mould merely took occasion of the injury to establish itself, and the exigencies of its mycelium completed the mischief.

514. There are abundant cases in which it is necessary that the cultivator should be able to distinguish accurately between decay aggravated by or immediately arising from the presence of parasitic fungi. In the one case he has a tolerably certain remedy; in the other he can only palliate evil, which in many instances may have gone so far as not to admit of remedy.

515. Having once established the fact that diseases do arise from fungi, the remedy according to circumstances may be either a preventive of anticipated evil or a cure of evil already existent. The remedy which is applicable in the one case may be totally inapplicable in the other. It is probable that the spores of Bunt would not be destroyed by crude sulphur, and it would be dangerous to apply strong metallic poisons to growing plants, as the remedy might be as bad as the disease. It will be necessary therefore in practice to remember this distinction.

516. *(Ascomyces). Ascomyces* is one of the simplest of fungi. It consists of an almost rudimentary mycelium producing at once without the intervention of any sporophores short clavate or obvate asci, each of which contains 8 or 16 ovate or subelliptic sporidia, which, as is generally the case with the whole plant, are of a pure white. It is evidently the simplest condition in which an ascomycous fungus can exist, and it is this circumstance that Montagne and Desmazières had in view when they proposed the name, which indicates a fungus composed entirely of asci, that is of hyaline sacs producing sporidia from the organisation of their grumous contents.[7] This however is not the whole structure which the plant presents. Besides the asci, there are very short necklaces of spores, consisting of from three to four individuals, and occasionally a spore is seen pullulating at the side exactly after the fashion of yeast globules. The question then arises, what is the nature of these secondary bodies; are they a further development of the sporidia, or are they a secondary form of fruit like the *Oidium* which constantly precedes Erysiphe? I am inclined to the second opinion, because I do not know of a single instance in which sporidia germinate after the manner of these bodies. We have then, even in so very simple a fungus, a secondary form of fruit, but whether both are capable of germinating I am unable at present to say.

517. The genus was first proposed by Montagne and Desmazières in the place cited above from specimens collected in the South of France on the leaves of *Quercus coccifera*. It affects almost exclu-

[7] For the characters of the same see Ann. d. Sc. Nat. Sér. 3. Vol. XI. p. 344.

sively the under surface, and generally makes the leaves more or less bullate. This species is characterised by its blueish tint, inclining in age to yellow or tawny. A second species which still remains undescribed distorts the leaves and stem of *Trientalis Europaea* in Scotland and was sent to me many years since by Dr. Dickie and Mr. Gardiner. A third occurs very commonly on the under side of Walnut leaves, in which it makes little bullate patches. This is *Gymnosporium leucosporum* Mont. It is however constructed just like the others, as I ascertained from specimens last autumn gathered by myself. Dr. Montagne had seen only the secondary form of fruit, and therefore considered it as belonging to a different genus. A fourth is described by myself in the eleventh volume of the Journal of the Horticultural Society of London. It formed shallow bullate spots on Pear leaves, and was referred by me to *Oidium* on account of the secondary fruit, as I had mistaken the nature of the asci, considering them merely as the transformed cells of the matrix. An examination of the species on Walnut leaves convinced me of my error, which I am glad to correct. A fifth species, perhaps the most curious of all, has been sent to me from various quarters during this and the past year. It forms enormous blisters on the leaves of Peach trees, which are strangely distorted and thickened very much in the same way the curled leaves are which are supposed to be produced by cold but dry and ungenial weather in spring, accompanied by a bad state of drainage, in consequence of which the leaves cannot get rid of their superabundant moisture, and therefore find a vent in the formation of new tissue.

518. It is doubtful whether any material injury is done to the plant by these fungi except in the case of the *Trientalis* and Peach. In the former instance the plant is nearly destroyed, as it is not the leaves alone which suffer; in the latter there can be no doubt that the health of the tree must be more or less affected according to the urgency of the case. It is obvious that if danger or injury is anticipated, the best plan is to dust the leaves well with sulphur, or syringe them with some solution containing sulphur, which latter may be the better plan, as it is the under side of the leaves which is principally affected.

519. I should have been glad to have studied this in connection with the Peach blister, but I have found it impossible to procure specimens during the last two years, though it was formerly a very

prevalent affection.[8] In the Peach leaves affected by the *Ascomyces* I find interposed between the cuticular stratum and the oblong cells which succeed it in healthy leaves eight or more layers of merenchymatous[9] cells. It is to these that the incrassation of the leaves is due. The under side does not seem to be much deranged, except perhaps that there are fewer and smaller intercellular spaces. The spores, both within and without the asci, were yellow with iodine, and were not altered on the application of sulphuric acid.

520. (*Erysiphe*—Mildew). The word mildew, which is derived from the German (*mehl thau*—meal dew), properly denotes those white and mealy fungi which infest the leaves of various plants in summer. They are familiar objects to every cultivator, but are widely diffused, and often so conspicuous that they cannot fail to attract the attention of all who are gifted with observant eyes. It is scarcely possible to walk in the woods in autumn without seeing many a young Maple bush as effectually powdered as if a quantity of flour had been dredged over it, and though this is perhaps the most conspicuous case, there are many other plants which suffer almost as greviously. The Hop, the Vine, the Rose, the Hawthorn, the Peach, the Strawberry, and various other plants, whether in the stove or in the open air, are often damaged by the little parasite, which may either advance no further than the white mealy stage as is the case with the Vine mildew, or may put on entirely new characters as the Hop and Pea mildew.

521. In the mealy stage the mildew to the naked eye, unassisted by magnifying powers, looks extremely like flour sparingly scattered. In same parts it is spread more thickly than others, and there are

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[8] Since the above was printed I have obtained a good supply of curled leaves from the Chiswick Gardens. Their structure agrees with what I have described above, except that the intercalated cells are as often parenchymatous as merenchymatous, and that the oblong cells are occasionally quite obliterated with very few intercellular spaces on the under side. In one specimen the *Ascomyces* was just formed, and I am inclined to believe that the little fungus has quite as much to do in the matter as climatic conditions. One of the little asci burst under the microscope as I was observing it, and amongst the sporidia ejected was one with an additional cell. It is possible, then, that it may be necessary to modify the opinion expressed above as to the Oidioid fruit. I shall hope soon to have an opportunity of studying the matter with good specimens, and assisted by the new light which has been thrown upon the subject by the Chiswick specimens.

[9] Merenchymatous cells are not so closely pressed as parenchymatous, and therefore do not present flat faces. It is not, however, meant that the cells do not exercise any mutual pressure.

generally little white specks in which it is collected into little heaps. Examined under the microscope it is found to consist of necklace-like threads springing from a creeping mycelium which either clothes the surface, sending down little suckers which adhere firmly to the leaf and ultimately decompose its tissue, or else it crawls amongst the intercellular spaces, sending up the fertile threads from the stomata. This perhaps may depend in some measure upon the nature of the surface. Where there are few or no stomates on the upper surface of the leaves, as in the Vine, the habit may be different from what it is on the under side, which abounds in stomates leading to ample intercellular cavities. The effect in either case is the same. The mycelium in the one case as completely as in the other exhausts the leaf and diverts the nourishment which was intended for the plant.

522. The joints of the necklace-like threads or Oidium vary somewhat in form, being sometimes cylindrical, sometimes elliptic, and sometimes swollen like a tun, but there are no very striking differences. After a time the upper joints fall off and germinate, and thus propagate the plant with great rapidity. Nor is it very nice as to the object on which the spores fall. The Grape mildew, for instance, may be communicated to plants placed beneath the Vines, or on which the spores are thinly sprinkled.

523. Sometimes instead of the joint itself germinating, its endochrome, without any increase of size in the joint, becomes organised, and gives birth to multitudes of minute sporidia, each of which is capable of germination within the external cell, so that the original spore looks like a little hedgehog, in consequence of the germinating threads projecting from its surface in every direction.

524. Some of the joints, however, put on a totally different structure. They swell immensely without however losing entirely their original form, their outer coat becomes organised and cellular, in which case they are called pycnidia, and finally they give birth to myriads of little oblong bodies which are sometimes capable of germination. It is conjectured that they answer some end of impregnation. But this is very doubtful. They are entirely destitute of motion and external appendages, and are probably mere representatives of the spermatozoids of higher plants.

525. Some species never go beyond this stage, or have not been observed to do so, as is the case with the Vine mildew; but more frequently little knots appear upon the creeping threads which gradually swell and form globose perithecia, surrounded by one or

more whorls of threads which are often singularly beautiful in point of form and symmetry. These perithecia sometimes, like the pycnidia, contain nothing more than a mass of minute oblong bodies of doubtful character; but in other cases they increase in size, and contain a variable number of sacs or asci, each of which in its turn contains from two to eight sporidia, or some larger indefinite number. The asci are generally of large size, as are frequently the sporidia, which germinate readily.

526. We have then five different forms of fruit, three of which at least have the power of reproduction. We need not then be surprised at the immense rapidity with which they are developed, or the immense mischief which they cause by their parasitic habits. It is more especially in dry weather that they flourish, though when once established it is not a little adverse weather which effectually checks them. Indeed unless some remedy be applied at an early stage of growth they run their course, whether that is confined to the Oidioid stage as in the Grape mildew, or the parasite proceeds to form perithecia as in the Hop mildew, and the end is the more or less complete destruction of the plant on which they grow.

527. The cultivator, then, must carefully watch for the very first appearance of his enemy, and at once apply the prescribed remedies. A very slight degree of intelligence, without the aid of more than a common pocket lens, will suffice to show him what he has before him.

528. *(Grape and Hop Mildew).* Though perhaps as many pamphlets have issued from the press relative to the Grape mildew, as a year or two before its first recorded appearance were published respecting that other kindred pest which attacked the Potato, there has not been such a persevering opposition to the explanation which seems the least beset with difficulties, viz., its origin from the attack of a parasitic fungus. At the present moment there is scarcely a person of any weight who refers the Vine mildew to any other cause, though a few scattered notices, alleging the most different and improbable causes, appear from time to time in our journals, indicative of an utter ignorance of the subject on the part of those by whom they are put forth. The consequence has been that proper remedies have been perseveringly applied, and these so efficacious that the Vine-dresser will have himself only to blame if he suffers any longer from this troublesome pest.

529. The Vine mildew made its first appearance in the east of Kent in 1845, and was in 1847 recognised as a parasitic fungus, to which the name of *Oidium Tuckeri* was given, after the cultivator

who first studied its growth. Amici, however, observed a short time later a transformation of the joints of which the little mould is composed, which seemed to indicate a higher affinity, and as this same transformation takes place in the Hop mildew, as noticed at a still earlier period by Dr. Plomley, it is more than probable that both belong to the same genus. The Vine mildew has not yet been seen to put forth that fruit which is normal in the mildew of the Hop.

530. As every species of *Erysiphe* in an infant state is an *Oidium*, and the supposed species of that genus are with great difficulty distinguished from each other, while very different species of *Erysiphe* may commence with a very similar *Oidium*, it is quite uncertain whether the mildew of the Vine is referrible to some old species, or whether it may not be a mere state of some species which fructifies on a different matrix. All that is certain is that Vines were not observed to suffer till the date above described; that the disease soon crossed the channel and made its appearance in the northern vineyards of France; that it spread from the original nucleus to the north and south, travelling however far more rapidly towards the warmer countries, and even crossing over to the United States with imported Vines, though the varieties of *Vitis Labrusca*, from which all the American Vines of better quality have sprung, whether in their own or in foreign countries are uniformly exempt.

531. Vines were attacked in Switzerland some years since by a white mildew, the spores of which were so abundant that the coats of those who passed through the Vineyards were as white as if they had been in a flour mill.[10] This fungus, too, consisted of necklaces of spores, but judging from the figures and description, which represent it as branched, it appears to have been different from the more modern plague. Should it turn out that the Vine mildew is a mere modification of some common form, we must look for the immense development of the parasite to climatic conditions, which, on close examination, may prove as remarkable as those which ushered in the cholera on its first appearance in England.

532. The more exposed the Vines are to prevalent winds and the higher they grow the more are they subject to attack. Vines which grow in the form of bushes are far less liable than those which are trained high on trellises. Under all circumstances the certain remedy is sulphur, either in the form of powder, or in solution of some of its combinations, in which sulphur is deposited in an impalpable powder,

[10] See Duby, Note sur une maladie des feuilles de la vigne, &c. Mém. de la Soc. de Phys. et d'Hist. Nat. vol. 7.

on the addition of an acid, and sulphuretted hydrogen given off. That portion of the sulphur which is precipitated, or which was applied in the form of a powder, combines, as it should seem, with the nascent oxygen, which arises from almost every vegetable process, to form sulphurous acid, which is destructive to the mould. If these methods are not approved, sulphurous acid may be generated at once in closed buildings from burning sulphur; but in this case care must be taken that the Vines themselves do not suffer.

533. The Hop mildew is so essentially the same with that of the Vine that the same observations in great measure apply to both. The same remedies may be used with the same good effect, a fact which is now appreciated by all intelligent Hop growers to their great benefit. The Hop factors were at first prejudiced against the practice, and refused to buy from those grounds in which sulphur had been used; but when it became generally known that Hops are always submitted to the fumes of sulphur in the ost[11] house, it was impossible to contend that injury was likely to ensue to the produce of the growing plant from the application.

534. Wherever white fungi appear, at least where the fruit is superficial, sulphur may be applied with great advantage. As regards the Peach mildew, practice had taught its value long before the Grape mildew was thought of, and it will be found equally efficacious in the case of Strawberries and other plants which suffer from similar attacks.

536. *(Cyttaria).* *Cyttaria* is not only remarkable for its large size, its comblike aspect, its frequently tufted habit, and its affording for many months of the year a valuable article of food to the Fuegians, but also because a fresh crop of fungi grows on the living branches from the same mycelium year after year. A similar habit occurs in *Podisoma* and its allies, and the parasite flourishes till the branch is finally exhausted. *Cyttaria* is confined to species of evergreen Beech. Faint traces of mycelium are visible where the fungus has fallen off, but not to such an extent as might be imagined in a plant of such enduring habits. The genus is confined strictly to the southern hemisphere.

537. *(Rhytisma).* *Rhytisma* is equally a true parasite, but of very different habits. It is intimately united with the tissues of the plant on which it grows, sometimes affecting the bark, sometimes the leaves. Species occur on the perennial leaves of *Andromeda* and *Ilex*, as well as on the deciduous leaves of *Acer*, *Vitis*, and *Salix*, or the herbaceous

[11] Probably derived from the German Obst, a term applied to all kinds of fruit.

foliage of *Aster* and *Solidago*. The species are seldom of such size as to be really detrimental. Those on the leaves of *Aster* and *Salix* are the most conspicuous, and that on the bark of the latter the most destructive. Fries observed that, in spring, the sporidia are discharged in a visible smokelike cloud from the fallen leaves, just as the new and tender leaves are expanding, and are thus enabled to establish themselves on the opening foliage. In *Salix* there is a thick white stroma, and the fungus is so highly developed that it must make important demands on the strength of the plant. *Dichæna*, which is very nearly allied, infests the living bark of Oak and Beech in England, but is not confined to those genera. I have it on *Cyrilla* and other trees from the United States. It is one of the plants which oscillate between Lichens and Fungi, and which show their intimate relation. Some of these species at first insinuate themselves between the true and false cuticle. In some cases the true cuticle is not ruptured till a very late period, or may remain intact so long as the parasite flourishes.

538. *(Dothidea)*. *Dothidea* also contains numerous species which live at the expense of previously healthy tissues; but in general they are so small as to be unimportant, except in the case of some exotic species. An exception, however, must be made as regards *Dothidea typhina* Fr., which is, however, now referred to *Hypocrea*. It lives upon the flowering stems of various Grasses, preventing altogether the evolution of the spike, and presenting instead an orange-coloured cylinder surmounted by a portion of the stem, so as to resemble a Bullrush. It is fortunate that cereals are never attacked by this fungus, or the destruction might be very serious, for where it occurs it is generally in great abundance.

539. One of the most destructive of the group is perhaps *Sphæria morbosa* Schweinitz. This is extremely common in Pennsylvania, but scattered about in other states, as in South Carolina, and is most injurious to native Plums, but never in them producing actual death. Cultivated Cherries, especially the Morella or Amarella, fare, however, worse. Schweinitz relates that this variety 40 years before he wrote was common in Pennsylvania, but a few years after the variety died out partly from its attacks and partly from those of a Cynips, its companion. The Greengage and some other Plums never suffered at that time, but at a later period they also failed. Meanwhile the swellings produced on the branches, which were at first small, acquired a foot and a half in length, but were never loaded so thickly with perithecia as when growing on the Cherry. I have numerous

specimens of this species from different parts of America all presenting the same gouty aspect, and rough with innumerable perithecia. This species has not yet made its appearance in England, but should it once arrive, there is little reason why it should not establish itself like some other exotic parasites.

541. (*Cordyceps*[12]—Ergot). The seeds of many Grasses and some *Cyperaceae* are subject to a very curious affection, which has long been distinguished under the name of Ergot. One form is familiarly known in our own country as spurred Rye; but the affection is scarcely less common in Wheat or Barley. Various causes have been assigned for this production, and various names given, but it is only within the last eight or ten years that its real nature has been ascertained.

542. The older observers looked upon it as a mere diseased state of the corn, without much inquiry into its cause. In Sowerby's Fungi the species or varieties are figured under the name of *Farinaria* (tab. 326, figs. 4, 6). Later writers referred it to *Sclerotium,* a genus formed to receive all fungi of a solid texture without evident fruit. From *Sclerotium* it was separated under the generic name of *Spermœdia* by Fries, under a notion that it was not truly a fungus. Leveillé considered the essential part of the fungus to consist in a wrinkled portion at the apex, a fact which has in part been confirmed by later writers. Queckett attributed it to a minute parasitic mould to which he gave the name of *Ergotætia.*

543. Meanwhile a curious *Sphæria,* now assigned to the genus *Cordyceps,* had been figured in the Flora Danica as springing from what was there called a seed, but which was evidently an Ergot. This species was published in Klotzsch's Herbarium Mycologicum, as growing on Ergot, together with another also on Ergot. Cesati, however, who communicated the specimens did not boldly assert the fact of the Ergot being a condition of the *Cordyceps,* but remained more or less in a state of philosophic doubt. Whatever credit may be attached to his observations, they were published at least as early as 1848. Corda had also in the Œkonomische Neuigkeiten figured a sort of hymenium in Ergot, which induced him to refer it to the genus *Hymenula.* Tulasne's observations were published in 1853, and if they were not absolutely new they had at least, without a knowledge of Corda's and Cesati's memoirs, the merit of placing the real nature of the substance beyond doubt. If the Ergot is sowed like common seeds, with proper attention, it uniformly produces a *Cordyceps* distinguished by perfect ascigerous fruit, while at an

[12] Claviceps is substituted by some authors.

earlier stage the surface of the Ergot exhibits a quantity of stylospores resembling closely the spores of *Hymenula.* The only doubt that has been thrown upon the matter is that Cesati has seen the same Ergot producing two species of Cordyceps, a fact which has been confirmed by Mr. F. Currey, from whom I have lately received an illustrative specimen. This, however, does not seem to me to militate against Tulasne's doctrine, for it is possible that the sporidia of two species of *Cordyceps* may be equally capable of affecting the grain of the same Grass, though the ergoted grains arising from the action of the two species may not be distinguishable; and even supposing that at one and the same time the Ergot might produce *Cordyceps purpurea* and *microcephala,* no reason can be adduced why the sporidia of either species should not concur in the production of the Ergot, and consequently when the Ergot is committed to the ground either species or both may spring from its surface.

544. One step towards the eradication of any disease is clearly a knowledge of its cause. If, then, the intimate tissues of the plants are not infested with the parasite, it may be hoped that by steeping the grains of those species as Rye and Barley in which Ergot is most common, its attacks may be prevented. Should however the Ergot have fallen, and the *Cordyceps* have in consequence been produced, if two white crops follow each other in succession, the latter may be affected even though the seeds have been steeped. Besides the sporidia are so minute that the slightest breath of air might take them to almost any distance, for they would not readily fall when once wafted upwards, except carried down by rain.

545. It is a great mistake to suppose that Wheat is very rarely affected. Ergot sometimes forms a large portion of bad samples of Wheat, though its nature is little known to our English farmers. In Barley it attains a large size and is very conspicuous. In Wheat it is but little larger than the ordinary grains, and sometimes occupies the same grain with Bunt.

546. Rye is so little grown in this country for food, that we seldom if ever hear the same complaints of the evil effect of Ergot as on the Continent. The free use however of bread into the composition of which a large quantity of Ergot enters, is followed by the most distressing and fatal gangrene. Its medical uses in the contraction of the uterus are well known, and there is no doubt that ewes and heifers often slip their calves when it abounds in a pasture. Farmers therefore should on no account turn in breeding stock where Ergot abounds. It is often very common on bents of Rye-grass in autumn.

547. Though the accounts of the action of Ergot when used for a continuance upon the human frame are beyond doubt, its occasional use may pass off with impunity. Children on the Baltic coasts often eat it under the name of St. John's bread without experiencing any evil consequences.

548. *(Antennaria, Capnodium).* The genus *Erysiphe,* which has been shown to be the cause of many of the affections to which both our indigenous and culinary plants are subject, does not seem to extend to very warm climates. In such localities its place is taken by the closely allied genus *Meliola,* which instead of producing a white mycelium has one which is jet black and the fulcra which surround the perithecia are of the same sooty tint. It is principally on the thicker leaves, but by no means exclusively that this genus is produced. The species are principally tropical, but they occur in Chili, New Zealand, and the United States.

549. There are, however, other black mildews which have a similar habit, and are indeed scarcely distinguishable without the use of a lens, which are far more widely and copiously diffused, and in consequence more destructive. These are not to be confounded with the olivaceous smokelike fungi which are so common in autumn on the leaves of trees which have produced honeydew. They belong to quite another category, and have a less pure black than those which are at present before us, and a very different structure.

550. The first which require attention are those cases in which the parasite on examination presents the characters of *Antennaria,* consisting of branched moniliform often echinulate articulations, some of which swell out into a sporangium, which either contains minute spores, as in the accompanying figures of *Antennaria Stephensii* Berk., or young plants in miniature (see *Gardeners' Chronicle* 1844, p. 851), which are at once developed under favourable circumstances on the rupture of the walls. These are not very common in our own country, but in some countries they abound to an excessive degree, and no where more than in New Zealand, the Auckland and Campbell Islands, and other localities in the southern hemisphere. In one species (*A. scoriadea* Berk.), the threads project so much from the matrix and are so intricately branched and compacted as to look like cinders, and approximate to the American genus *Scorias* which covers various vegetable substances with a moist black spongy crust two or three inches in thickness.

551. These *Antennariae* are the pests of the Coffee and Orange plantations in Ceylon and the Azores, and as the common *Fumago*

generally accompanies honeydew, whether arising from Aphides or other causes, so these affections seem generally to wait upon the attacks of a species of Coccus. They have extended so widely of late years as to make cultivation very precarious, and at present no effectual remedy has been discovered, though it is probable that sulphur may have the same effect on them as on other epiphytous fungi.

552. Though the characters of the genus *Antennaria* appear so strongly marked . . . it is now pretty generally acknowledged that the genus in not autonomous, but merely a condition of the genus *Capnodium,* which in external appearance is identical with it and which often attends or follows the *Antennaria,* and this under such varied circumstances as to make it quite certain that the one is merely a form of the other. In *Capnodium* perfect perithecia are formed by the matting together of the component threads of the matrix, or at least they run up and are incorporated with them. These are generally very much elongated, and often strangely branched, and in several cases perfect asci and sporidia appear, as is the case also with the closely allied genus *Scorias.* The geographical distribution, as might be expected, is almost identical with that of *Antennaria.* The true fruit is not, however, invariably produced where the *Antennaria* stage is perfected. In this country, for example, *Antennaria* occurs occasionally without progressing to the stage of *Capnodium,* but there is a little species which is common on Laurels and other evergreens which constantly perfects its perithecia.

553. On the continent the species, when in the form of *Antennaria* or *Capnodium* or both united, are far more common. One of these, *A. Stephensii* or *C. Citri,* as imported on Lemons is far too familiar an object to our fruit dealers. It is no unusual thing, on opening a box just imported, to find the greater part of the fruit covered with a dense velvety coat, exhibiting in parts the characters of *Antennaria,* in parts those of *Capnodium,* which must have grown principally on the voyage, as it is scarcely conceivable that the fruit could have been packed in such an unsaleable condition. The loss however in consequence is not absolute, as a portion of the fruit when brushed looks tolerably well, but it is evident that its keeping qualities must be much impaired by such a process.

554. In stoves where *Capnodium* is most likely to occur, extreme cleanliness and timely sponging will prevent the accumulation of these very unsightly plagues. I have not however met with any instance of their appearance. A long account of the species, with

abundant figures, will be found in the fourth volume of the Journal of the Horticultural Society of London.

555. *(Botrytis).* This name is familiar to the English reader from its connection with the Potato murrain, but as if nothing in nomenclature was ever to remain unchanged, three names at least, *Peronospora, Bremia,* and *Monosporium* have striven to supplant it, and the former with some prospect of success. Unhappily when extensive genera are divided, the division is seldom made by authors who have studied the whole group, and have therefore reserved its proper place to the original name, which ought to contain the more typical species. Each, for the most part, separates a group under a new generic name, till the original genus is lost. The genus *Botrytis* was first established by Micheli to include the species which were afterwards separated under the name of *Polyactis* by Link. Meanwhile a parasitic species, the mould of many Crucifers, was proposed by Persoon under the name of *Botrytis parasitica,* and the species is figured by Sowerby as *Mucor Botrytis.* Many species were subsequently added, which form *Verticillium* and other genera, and *B. parasitica* and its allies remained tenants of the genus till Corda, without considering what had been done by others, according to his habit of giving every form a new generic name, proposed for them the name of *Peronospora,* while Regel, in ignorance of a host of publications on the subject gave to one species the name of *Bremia,* and Bonorden added that of *Monosporium.* Under these circumstances, unless the name of *Botrytis* is to be swamped altogether, it seems right to retain it for the plant of Persoon and its allies, as the genus *Polyactis* is well established, and can scarcely have its proper name restored.

556. The parasitic species of *Botrytis,* to which it is proposed to confine the name, consist of a branched mycelium creeping amongst the large intercellular spaces of the under side of the leaves of plants, or occasionally amongst far closer tissues and fertile threads rising from them which penetrate into the open air or some free space, and there produce at their swollen or branched and often forcipate tips, large globose ovate or elongated spores. Tulasne, Caspary, and others have however discovered that this is not the only fruit. The latter, independently of Tulasne, has figured[13] two kinds of fruit, one of which containing a single many-coated spore he calls a sporangium, and the other a cell containing multitudes of minute sporidia he calls

[13] Ueber zwei-und dreierlei Früchte einiger Schimmelpilze (Hyphomyceten), von Dr. R. Caspary. Berlin, 1855. An extract from the monthly report of the Berlin Academy, May 1855.

a sporidangium, an organ which differs from the pycnidia of Tulasne in its simple covering and the reproductive bodies like those in the vesicles of *Mucor* being formed from the protoplasm. These forms of fructification have not been discovered in every species at present, and as the *Oidium* of the Vine has not yet been found producing the fruit of an *Erisyphe,* so the *Botrytis* of the Potato has at present not been found with sporangia or sporidangia.

557. The parasitic species of *Botrytis* occur on plants of various kinds, and are very numerous. In South Carolina a very handsome species grows on Vine leaves without however being produced in such abundance as to do much mischief. In our own country the ravages are often extensive. A lilac-coloured species abounds on Spinach and other allied plants, forming close dense tufts. Peas, Poppies, Teazle, Lettuces, Parsnips, and above all these various species of Onions, often fall a sacrifice to their attacks. The species which affects the latter, *B. destructor,* is like the mould of Spinach tinged with lilac, but instead of forming a close felt is scattered uniformly over the leaves. The spores are longer than in any other species. In the species which attacks *Rhinanthus, B. densa,* the spots are definite, and the stems very short and of a pure white; in *B. ganglioniformis,* [*Bremia lactucae*] the pest of Lettuces, but which also grows on the Sowthistle, the tips of the threads, instead of being regularly forked, swell into ganglion-like processes, from which little spicules project, each of which is surmounted by a spore. On the *Anemone* the fertile threads are still shorter than in the *Botrytis* of *Rhinanthus,* and are very slightly divided, so as to bear only four or five spores.

558. The threads of the *Botrytis* are injurious in two ways, first by diverting and appropriating the nutriment which was elaborated by the plant on which they grow, principally as it should seem by endosmose through the walls, though the threads are capable of penetrating the cavities of the cells, and secondly when they themselves decay, by acting like a putrefactive ferment on the tissues with which they are in contact. It is manifest that if this be the case it is not necessary that the *Botrytis* should penetrate to every part where decay exists, for when the tissues are once affected at a particular point they can communicate the taint as well as the fungus. The *Botrytis* which attends the Potato murrain is so important as to require a separate article.

559. (*Botrytis,* Potato Murrain). It is now so universally acknowledged that the Vine disease is due to the attacks of a parasitic fungus,

that there ought to be no difficulty about the reception of the cognate theory as regards the Potato murrain, a theory respecting the justice of which I have never entertained a doubt. The only theory which at the present day can at all compete with it, is that maintained by Schleiden and others, that it is the result of high cultivation, a theory which shall be fairly stated at the end of this article.

560. In considering the Potato murrain it must be borne in mind that there are two distinct diseases of the Potato, each characterised by the presence of a fungus, which may and often do occur separately, but which may also simultaneously attack the plant. These diseases are distinguished by the Germans under the name of *nassefaüle* and *trockenfaüle*, the wet and dry rot. They are in some respects antagonistic to each other, though both concur in the final destruction of the tubers.

561. The last is called the disease of Martiuś, from its having been described by him in 1842. It is characterised by the presence in some of its forms of *Fusisporium Solani*. The affected tubers are traversed in every direction by mycelium, which gorges the tissues to such an extent that they become excessively hard, so as to require many heavy blows before they give way. The degree of hardness is not always equal, and in some cases, at least in this country, the *Fusisporium* may exist alone on the Potatoes while the tissues are moist. According to the degree of dryness the parasite assumes many distinct forms, and has been described under several generic names. This disease had existed in Germany for many years, and had become so prevalent at the time when Martius wrote as to make the successful cultivation of Potatoes any longer in Germany a matter of doubt.

562. Just as the disease of Martius had attained its height another malady, characterised by the more speedy dissolution of the tubers and the presence of *Botrytis infestans*, made its appearance. It was extremely destructive in some part of the United States in 1844, and was noticed in England and on the Continent in that and the preceding year, but in 1845 it became almost universal, and from the great importance of the subject attracted general notice, though scarcely anyone anticipated the horrors of the consequent famine, or the enormous political changes to which it gave rise. The disease in most cases, and with most varieties, commenced in the haulm and leaves. Little patches of *Botrytis* were observed which soon reduced the tissues with which their mycelium was in contact to a dead patch, which spread in all directions as fresh crops of the Botrytis sprang

up like Fairy Rings in a Grass field on the circumference of the exhausted soil. The tissues of the stem were rapidly involved, and finally the more superficial portions of the tuber. Where there was no superabundant moisture the decay of the tubers was not so rapid as that of the green parts of the plant, but under less favourable circumstance a few hours produced an extraordinary effect, and in some cases which were witnessed by the Government Commissioners in Ireland, in four-and-twenty hours large heaps were reduced to a loathsome putrescent mass. According as the *Botrytis* existed alone or in combination with the *Fusisporium*, the decay under the least pressure of unpropitious atmospheric influences exhibited a greater or less intensity.

563. Multitudes of remedies were proposed, but for the most part with very little success, nor is the crop such as to admit of very expensive chemical applications at the cost of additional labour and expenditure. The most effectual, perhaps, was the cutting off of the haulm before the fungus was established. From the low growth, and the occurrence of the fungus principally on the lower surface of the leaf, it is almost impossible to get sulphur fairly in contact with the parasites. Where the air is naturally impregnated with salt, in the neighbourhood of the sea, or artificially with chemical vapours, as near copper works, the disease has been wholly absent or far less virulent. The whole surface is there accessible, a condition not very easy to realise in practice. There is much reason to suppose that the disease is gradually dying out, though virulent attacks, as at this present moment, have occasionally occurred in almost every district without intermission since its first prevalence.

564. The Schleidenian theory rests on the fact that the tissues of plants, which consist partly of cellulose and partly of proteinous matter in contact with starch, inuline, gum, sugar, and other substances capable of fermentation or chemical change, are easily deranged under any alteration of their normal ingredients. If, then, an increased dose of nitrogen be taken up from the soil in consequence of the use of highly nitrogenous manures, the balance as a necessary consequence is deranged and putrefactive fermentation ensues. The difficulties in the way of this theory are quite as great as in the other, and when once the prejudice is removed that fungi can only grow on decaying or decayed vegetable matter, a notion which is opposed by a host of facts, there is little objection to be brought against what is commonly called the Fungal theory. The one cause, however, may greatly aggravate the other, and the cultivator should be in-

structed that he cannot farm very highly without the prospect of danger. His direction should be turned rather to more frequent and effectual stirring of the soil, and the thorough extirpation of all obnoxious weeds. Under such a system he will insure a good return, and at the same time have a healthy vegetation, while ample work is provided for the labouring poor, to the general comfort of himself and neighbours.[14]

565. *(Stemphylium, Macrosporium, Sporidesmium, Helminthosporium).* The two first of these genera may perhaps be safely reduced to one; the third is distinguished by the almost total absence of sporophores, while the fourth has in general very dark and well developed fertile threads and spores with numerous horizontal but no vertical articulations, which are normal in the two first, and are not alien to *Sporidesmium.* In the present notice I shall consider principally those species which decidedly belong to the three first, reserving the last for a future number in conjunction with *Cladosporium.*

566. It is only of late years that anything has been said of the destructive powers of any of the species on living tissues. The species, like so many other fungi, were supposed to attack dead or dying parts of vegetables; but it was not imagined that they could establish themselves on sound and healthy tissues. It was however shown by De Bary that plants of Heath are attacked by a little *Stemphylium,* which runs over the tender foliage and soon reduces the healthiest plants to dry sticks. This has been especially noted in the Transactions of the Horticultural Society of Prussia, and specimens have been widely distributed by Rabenhorst under the name of *Stemphylium ericoctonum,* under which name it has been published. I have numerous examples myself by the kindness of Dr. Caspary. The plant is remarkable amongst other matters for exhibiting in different stages the characters of *Verticillium* and *Dactylium,* before it assumes its perfect form.

567. More recently two papers have appeared in the Botanische Zeitung, 1856, illustrative of a disease caused in Rape seed and Carrot by a little fungus referred by Amtmann Kühl to the genus *Sporidesmium,* but which appears more properly to be merely some *Macrosporium.* The details are far too lengthy to reproduce here, and they do not admit of much abbreviation. It appears, however, that the mycelium penetrates deeply into the substance of the mother

[14] Further views on this subject will be found in my article in the first volume of the "Journal of the Horticultural Society of London," and under the word Potato in "Morton's Encyclopaedia of Agriculture."

plant, and soon causes more or less complete ruin. The discoloured spots are at first punctiform on the pods, but striaeform on the stem and branches. They soon spread; the leaves hang down, and at length rot off without however being always attended by any affection of the root. The plant is easily propagated, not only between slips of glass in water or a damp atmosphere, but on parts of the Rape plant. Spores sprinkled over the pods produce a new crop in less than four days. The black specks soon appear as in other cases, and the delicate mycelial threads penetrate by means of the stomates into the subjacent tissue. The spores are very tenacious of life, and are readily propagated after they have been kept a twelve-month, a fact which probably is equally true of a great variety of moulds, and which accounts for their ubiquity. When the crops were still unaffected, in the beginning of June, the fungus was easily reproduced by sprinkling spores which had been saved from the preceding year; and in nature these are preserved on the dry stems and leaves, and perhaps in various other situations, for the fungus is not confined to Rape, but affects equally Carrots and Charlock.

568. The roots themselves are often infested with another parasite referred to *Helminthosporium*. This is published in the twentieth number of Klotzsch's Herbarium Mycologicum; but unfortunately I have not yet received the number. It is published under the name of *Helminthosporium rhizoctonum* Rabenhorst. The base of the root, and sometimes the middle but never the top, is covered with a dense violet-black coat.[15] The top of the Carrot is sound, but the base is soft and decayed, and soon after the root is removed from the soil other parasitic fungi establish themselves on the surface. It first appears in the guise of little scattered black specks. These soon become confluent, and throw out a quantity of mycelium, which is of lighter colour than the fertile threads, insomuch that various tints may be traced from white and rose coloured up to violet black. The mycelium does not penetrate beyond the subepidermal stratum, but the cells which are infested change their colour by a conversion of the contained matters into ulmates and humates. The leaves are at the same time affected with the same mould as the Rape, but distinguished from it as a variety by the greater development of the sporophores. In both alike the spores are multiseptate with a few vertical plates, and are either strongly clavate or acuminate. In the parasite of the Rape the spores sometimes produce new spores from their surface, or at their apices, and the process is repeated till

[15] See Kühn, Ueber das Erkränken der Möhren, in Bot. Zeit. 1856. Feb. 15.

we have the structure of *Alternaria.* In some again two or three are joined at the base, in which case we have a close approach to *Triposporium.* Unfortunately, though the species is very carefully described, the author is unable to suggest any remedy. The mycelium is too deeply seated to be easily affected by sulphur, a remedy which can scarcely ever be applied in such a case till it is too late. The best practice probably would be to give a good top-dressing of lime and sulphur, though the action of these unhappily is not permanent, since it affects only those parts of the plant which are already fully expanded. A fresh crop of the parasite will necessitate therefore a fresh dressing, the cost of which may exceed the probable return.

568. [sic] *(Helminthosporium, Cladosporium).* These two genera are so intimately combined that it is difficult to assign their limits. This observation applies more especially to those truly parasitic species which come under our present notice. They are very widely diffused, and occur in South Carolina, America, Ceylon, Hindostan and in other countries, though they are not found everywhere like *Cladosporium herbarum,* which is perhaps the commonest of all vegetable productions. The better opinion is, we believe, that which assigns them to *Cladosporium* rather than *Helminthosporium,* and this view is therefore adopted here.

569. The species which we have more immediately in view is that which attacks various *Pomaceae,* and not only has the one species been split into five or six, but has been assigned to almost as many genera. *Phlyctidium, Actinonema, Asteroma,* and *Spilocaea* have asserted their claims as well as the two placed at the head of our number. This confusion has arisen partly from the very different habit assumed by the species on different plants, or organs, and partly from the proper fruit being often undeveloped. *Cladosporium dendriticum,* such is the name given to the plant by Walroth, arises uniformly beneath the true cuticle under which its mycelium radiates in every direction, in which state, as upon the leaves of the common Service, it is referred to *Actinonema* or *Asteroma.* Sometimes it forms compact almost definite spots, when it is a *Spilocaea,* while very frequently the spots are more diffused, when it is considered an *Helminthosporium* or *Cladosporium.* Late in the year it assumes a very anomalous aspect. The spores germinate and form a dense spongy mass which abounds with conidia, and might readily be pronounced distinct. On the leaves of Pears and Apples, especially the former, it is a dreadful pest, exhausting their strength and often killing the young twigs, while on the fruit it makes unsightly black

patches, rendering it unsaleable, and sometimes inducing or else accompanied by extensive cracking, which adds still further to the mischief. When it has once attacked a tree it is very apt to return in the succeeding years. Moreover there is reason to believe that it is so inveterate, that where plants have been attacked by it, a new progeny raised from the seed of the diseased individuals will soon exhibit the parental malady. A singular instance of this is related in the *Gardeners' Chronicle*, 1848, p. 716. All the plants of the common *Pyracantha* raised from a particular packet of Russian seed were attacked by the *Cladosporium dendriticum*, and many of them were severely injured, while neighbouring individuals of the same species did not suffer.

570. Like all parasites which are produced beneath the cuticle there is some difficulty in applying a remedy in an early stage of the disease, nor is there evidence at present to show that sulphur is as certainly destructive to the brown as to the white moulds. In the present instance the better practice would be carefully to gather up the infected leaves as soon as they have fallen, at the same time trimming off the diseased shoots, and at once burning both. The tree might then be painted with sulphur mixed with tragacanth, or with sulphur and lime, in the hope that this might slowly act upon the spores which had been deposited on the buds. It is essential to use something which may make the dressing permanent. Sulphur by itself is insoluble in water, and if merely mixed with water or dusted on, is liable to be washed off before it has effected any good, which it can do only by combination with oxygen to form an acid.

571. *Cladosporium dendriticum* is in general very prolific in spores, but some of the exotic species rarely produce them, and are often found in the form of mere tufts of barren threads. *Spilocaea* which has long been a matter of perplexity to botanists, constituting the black spots so common on Apples, is we believe certainly a mere form, though the matter has hitherto escaped the attention of botanists. The spores are not of the same form or size on every Apple. We have seen them very different on Newtown Pippins from the usual British form. The spores however in the normal plant and in different varieties of it are so variable, that a similar phenomenon in abnormal conditions is not surprising.

572. *(Polyactis).* The moulds which belong to this genus are amongst the very commonest productions upon decayed or decaying vegetable substances. A dry leaf lying on the surface of the soil of a frame or garden pot, a plant which has just damped off, a diseased

Cucumber, &c., are soon covered with some one of the species, a good example of which is afforded by . . . *Polyactis fascicularis* Corda. The principal distinction between *Polyactis* and *Botrytis,* taking the parasitic species, as for example *B. infestans,* for the type of the latter genus, consists in the articulate slightly carbonised stem and difference of habit, the one growing on vegetables already more or less decomposed, the other on healthy plants, healthy that is till they have been attacked by the parasite.

573. Facts, however, have lately come to light which tend to prove that such moulds though not truly parasitic in their nature may at times act as parasites. They are developed on decaying matter, from which the mycelium spreads in the guise of long straggling threads over living leaves, the fine tips of which, as it should seem, enter the stomates, without however deeply penetrating into the tissues, and by their decay acting as a putrefactive ferment, from which death ensues. This statement is indeed at present partly theoretic, but it is of such importance that it is worth stating even in the absence of positive proof as to the mode of action. It is not indeed quite certain whether sulphur acts upon these carbonised moulds as speedily and certainly as upon those which like the oidioid state of *Erysiphe* are of a pure white, and we have evidence before us that very delicate plants may sometimes be injured by the application of sulphur, a fact which is not surprising, as the effect is probably produced by the conversion of a portion of the sulphur into sulphurous acid, a substance which even when so produced may easily exisit in such a degree of concentration as to be fatal to delicate tissues. The effect of brimstone fumes, which are the same thing, on plants of any delicacy, even when slightly mixed with the atmosphere is known more or less by fatal experience to every cultivator. The great desideratum at present in the cultivation of plants is to find some substance which will act upon the darker coloured fungi without affecting the plants on which they are developed. Since however when once generated they appear to be peculiarly difficult of control, the great point is to prevent their growth at first, or at any rate to preclude the appearance of a new generation. To the first of these particulars it is needful that all the materials of which soil is composed should be in a thorough state of decomposition. If half decayed fragments of vegetables exist either in contact with the roots or on the surface, mischief is frequently communicated by the moulds which are generated upon them. Where plants of the same kind are crowded in pots and one of them perishes and becomes mouldy the rest are

very apt to follow, not by inherent decay but from contamination of the dead plant, and it is this fact which makes it necessary to remove dead leaves which have performed their functions from crowded cuttings. Supposing, however, these moulds to have become inveterate, the only hope will be in the removal of the whole affected stock and thorough cleansing of the walls and washing with lime and corrosive sublimate. This is the only remedy in bakehouses where bread is subject to acquire a ropy fermentation, an evil which is due to the development of the spores of some noxious fungus, many instances of which have been recorded in France, and the same may be said of those silkworm establishments which have been affected to a ruinous extent by the mould which produces the disease called muscardine.

574. In conclusion of our remarks on *Hyphomycetes,* it will be well to advert to a paper just published by Tulasne in Annales des Sciences Naturelles on the dualism of fungi. Many facts have from time to time been brought forward to this effect, commencing with the speculations of Fries some 20 years ago. The subject has been followed out to a great length by Tulasne, who now extends the matter to a degree which could scarcely have been anticipated. Not only does he believe that the greater part of the naked-spored *Pyrenomycetes* are mere conditions of species which normally bear their fruit in definite number contained within sacs called asci, but he believes that far the larger part of the black moulds, as *Helminthosporium, Graphium,* &c., are the conidioid state of *Sphaeriae.* Nay, more, that *Stilbum, Atractium* and some other genera belonging to a very different series belong to the same category. It is evident that these notions can only be confirmed by long series of observations. Direct experiment unhappily can scarcely be brought to bear upon them in many instances. A few cases however well established will go a great way to their confirmation, and when the facts are once received as established truths, the whole subject of mycology must undergo revision. In a transition state confusion will probably be worse confounded than ever, but order will at length rise out of the chaos, and many a present cause of perplexity be removed forever.

575. *(Coniomycetes: Æcidium).* The order *Coniomycetes* contains far the larger portion of the fungi which are injurious to the farmer, and especially those which affect Cereals. The first genus which comes under notice, taken in its larger sense as comprising *Peridermium, Ræstelia, Graphiola* and *Cronartium,* besides typical *Æcidia,* is not however one with which he is much concerned, except

his farm comprise the manufacture of cider and perry, as is often the case in the west of England, when he will occasionally suffer considerable loss.

576. *Æcidium* proper has however some interest for the farmer, because one species is connected with the question as to the baneful influence of the Berberry on Wheat. The notion has undoubtedly arisen from the fact that the Berberry is so often rusty with *Æcidium Berberidis,* which has been confounded with the rusty appearance which so constantly precedes mildew in Wheat, and which is in fact the young condition of the plant by which it is caused. *Æcidium* consists of a tuft of long orange-coloured necklace-like strings of spores contained within a membranous sac which opens above in a radiating manner so as to present a very elegant appearance. The spores germinate as observed by Tulasne, and produce broadly cymbiform secondary spores of two orders. The spores of *Puccinia graminis* are brown and uniseptate, and on germination equally produce two kinds of secondary spores. Moreover in *Æcidium* there are spermatogonia filled with minute spermatia which are discharged in the form of little gelatinous drops or tendrils. In *Puccinia* spermatogonia are far more rare, but they have been observed by Tulasne. There is no doubt then that *Æcidium* is as perfect a plant as any neighbouring genus, and cannot therefore with any probability be supposed to be a condition of *Puccinia.* Authorities besides, whether scientific or practical, are by no means uniform on the influence of the Berberry, nor has experiment confirmed the common notion. Mr. Knight's experiments were not solitary, and led to no positive result, though in one instance, which if solitary might have misled him, there seemed to be some evidence in favour of the effect of the Berberry on Wheat. Staudinger, Hornemann, and Jussieu came on the contrary to a positive conclusion that the plant exercises no baneful influence. It should be remembered, moreover, that no districts are more subject to mildew than the fens, where the Berberry is wholly unknown except in gardens, and that the plant is comparatively rare in England, though abundant in some localities.[16]

577. Species of *Æcidium* proper occur on many plants of very various orders. Though there are undoubtedly many different species, it is quite certain that they have been multiplied beyond all reason,

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[16] See Henslow's Report of the Diseases of Wheat, in Journal of the Royal Agricultural Society; Staudingar on Ergot and Rust, in Isis, 1832, p. 262; and report on his paper by Montagne in Archives de Botanique, vol. ii., p. 283; and article Mildew in Morton's Cyclopaedia.

each different genus being for the most part supposed to produce its own species. The injury is not always considerable, but in some cases, as *Anemone coronaria, Sambucus canadensis, Euphorbia,* &c., the matrix is more or less distorted, sometimes acquiring in the Elder the peculiar appearance which is known under the name of Stag's Horn in the Ash and some other plants. In these cases the parts affected die as soon as the fungus has attained its full development, or shortly after, but if the leaves are affected without any general change of structure, the plant if perennial suffers only a temporary check which may be completely remedied the next season. In the Gooseberry the leaves are not the only part which suffer, but the fruit is often affected, acquiring sometimes a peculiar nauseous taste. And the species is sometimes so abundant as to diminish sensibly the saleable produce. The fruit of the Berberry likewise is affected as well as the leaves, and is then generally more or less distorted.

578. The spores vary in colour from white to pale orange, scarlet and brown, and the investing membrane, which with the aid of a needle may be picked out perfectly entire from the surrounding tissue, varies considerably in the degree of development and mode of rupture, and hence in a few cases the species are not easily distinguished from *Uredo* without attentive examination.

578. [sic] *(Peridermium, Ceratites, Ræstelia, Graphiola, Cronartium).* These are all subgenera of *Æcidium.* Of the two last *Graphiola* affects Palms and *Cronartium* species belonging to the genera *Cynanchum, Paeonia, Thesium, Quercus.* Both are of such slight consequence in a practical point of view to most cultivators, that they may be regarded as mere botanical curiosities. I have seen, however, *Graphiola* very troublesome in Palm-houses, impairing the beauty and exhausting the strength of the plants, but it is not common in this country, and *Cronartium* is very rare, if it is found at all. *Peridermium, Ceratites,* and *Raestelia* are of far more consequence, and deserve special notice.

579. *Peridermium* differs from *Æcidium* in the great development of the peridium and the irregular mode in which it is ruptured. According to the situation on which it grows and the degree of nourishment which it affords the peridium is more or less developed, sometimes acquiring a length of more than half an inch with a proportionately increased thickness. The species are confined to Conifers, which are sometimes distorted by them in a very curious way. One magnificent species was found by Dr. Thomson on *Abies Smithiana*

in Thibet of which the following is a faithful representation. One of the most curious species, however, is that which forms the clusters of branches which are known in Germany by the name of "witches' besoms." This very extraordinary production has lately occurred in great abundance near Hastings, from whence we have very recently figured specimens, transmitted to us by the kindness of Sir C. Lamb. The branches look exactly like some phaenogamous parasite. The fascicle springs from a swollen knot, the leaves are no longer distichous, but dispersed in spirals, and their form and texture is entirely altered. They are, moreover, deciduous, while the normal leaves are evergreen, and a new bud is developed from the tips of the naked branches every year, producing a tuft of leaves which are at first yellow, but at a later period acquiring a green tint, till the mass is at last exhausted. *Peridermium Pini* is the pest of the Scotch Fir in young plantations, and is sometimes so abundant in the branches as well as the leaves that death speedily ensues. No remedy for this evil has at present been suggested.

580. *Ceratites* is confined principally to *Pomaceae*, though one or two species oscillating between this and the following sub-genus occur on plants of other families in Ceylon. On Hawthorn, Quince, and some other *Pomaceae* it is often very conspicuous, attacking the fruit sometimes as well as the leaves. It is distinguished by the narrow strap-shaped lobes at the orifice of the peridium.

581. Perhaps the worst of all these pests is *Ræstelia*, which is so common on the leaves of Pear trees, occurring sometimes in such quantities as to injure greatly the fruitfulness of the trees. This has many characters in common with *Ceratites*, but the laciniae instead of being free are all connected together, so as to form a little cage through the interstices of which the spores escape. In both these is a second form of fruit distinguished by the oozing out of the spores or spermatia, whichever they may be, in the form of little tendrils. When a Pear tree is once attacked by this pest it seldom escapes in future years. On the contrary the evil generally increases, spreading to every neighbouring tree, and so propagating the desolation. The sooner it is arrested the better. When once it is observed every affected leaf should be carefully gathered and burnt as soon as it is gathered. It does not appear that any wash is of benefit, nor is it quite clear should experiments be made at what precise time it should be applied. The wiser plan is to pick the leaves as soon as the orange-coloured thickened spots appear before the spores are developed.

582. *(Tuburcinia).* This genus consists of two or three species, which prey upon the tubers or underground stems of plants, as *Orobanche, Monotropa, Linaria,* and *Solanum.* They differ greatly among themselves, and do not probably all belong to the same category, but as is the case with other hypogæous plants apparently similar, they may have very different affinities. In *Linaria spuria,* according to Tulasne, the affected plant does not seem to suffer in its general health from the parasite. It blossoms and perfects its seeds. How far this may be the case in other species does not appear; it is however certain that as far as Potato tubers are concerned, which is the important matter for cultivation, *Tuburcinia scabies* does considerable mischief. It is on account of this latter species that the genus requires notice in this place.

583. The parasite was first noticed by Walroth, then by Martius' Treatise on the Potato Disease,[17] and afterwards very briefly characterised and referred to the genus *Tuburcinia* in Mr. Berkeley's account of the Potato Murrain, which appeared in the first number of the Journal of the Horticultural Society of London, and a short notice of the disease is given in the third volume of the same journal, p. 37, in company with the malady commonly known by the name of Scab.[18] It is not confined to any particular sort of Potato, but is said to be more common upon white and yellow Potatoes than upon blue and red. It is by some attributed to injury in digging, as it sometimes makes its first appearance in Potatoes stored up for winter use; but it is far from unfrequent in the natural soil, where it sometimes destroys the crop altogether. The first appearance of the disease is indicated by little spots of a darker and less pure colour and less shining than the rest of the cuticle; they are orbicular in form and scattered over the surface, but they soon become confluent and probably from a slight degree of moisture the dirt adheres to these spots more than to the rest of the tuber. When the tuber is divided no difference is seen between sound and diseased individuals except an increased disposition to change colour on exposure to the atmosphere. According to the condition of the weather or temperature, and when the tubers are stored, the hygrometric condition of the air, the spots more or less speedily change their aspect. The cuticle begins to get loose, the subjacent parenchym changes colour and adheres closely to the skin, and at last little flat pustules appear

[17] Die Kartoffel Epidemie, p. 23, tab. 2, fig. 9-13.

[18] I have availed myself largely in the text of Martius' account, which is very full and circumstantial.

upon the surface, while their cuticle acquires a deeper tint, and the interstices become rugged and speckled. The tubers at first were not impaired in point of flavour, but now they have a faint disagreeable taste, which is communicated to everything with which they are mixed. If in this condition the tubers send out shoots they are weaker than usual and often go back.

584. The cuticle has hitherto remained entire. It now fails in the centre and exposes the underlying tissue, which appears dusty and assumes different colours. If, however, the peel be stripped off, the base of the pustule comes off with it, the whole of the tissue having assumed the same structure as is the case in the affection more commonly known under the name of scab. As the malady proceeds, the thick diseased skin at last shells off and the underlying cells make their appearance sullied with the greenish brown spores of the fungus. The tissue in the neighbouring portion is more or less discoloured and decomposed, and where the disease is very virulent, the pustules run so deep and prevent the full expansion of the tuber so completely that they are perfectly worthless. In some instances the pustules are so frequent that, as in the confluent smallpox, they occupy the whole surface.

585. A few scattered tubers are often affected by this disease. In some years it is scarcely possible to get a specimen, while in others the disease is so prevalent as to do great mischief. This was especially the case in 1847 in Cornwall and the Scilly Islands. As far as my own observations go it occurs principally in damp ungenial seasons in badly cultivated land, especially where Potatoes have been planted many years in succession, and where imperfectly rotted manure or mere rubbish has been applied.

586. As regards the parasite itself it was first named by Walroth *Erysibe subterranea,* his genus being equivalent with *Uredo* and not with the genus generally known under the name of *Erysiphe.* Martius gave it the name of *Protomyces,* and in the Journal of the Horticultural Society it is referred to *Tuburcinia.* The spores are composed of numerous cells, built up round a central cavity, with one or more apertures on one side leading to a large central cavity, and indicate a relation to *Sporidesmium* rather than *Uredo.* Their form is in fact that of a bomb-shell with one or more plane circular apertures. They are attached to delicate threads, as is the case with some of the large compound *Sporidesmia.* The only remedy against the evil is good cultivation, and especially the use of well decayed stable

manure, which seems to agree better with Potatoes where manure is used at all, than the mere refuse of the dunghill.

587. *(Ustilago,* Smut Dust-Brand*).* This genus contains some of the most formidable and destructive parasites which affect a variety of plants of very different characters, but more especially those Grasses which are cultivated for the nutriment of man and of those domestic animals which form so important a part of his food. They differ considerably in colour and character, varying from purple or lilac to violet and olive brown. Those species which affect Cereals are all of a dingy tint and of very simple structure. The bodies, however, which are commonly known by the name of spores are merely the first effort of vegetation. They germinate when placed under proper conditions of moisture, and produce by means of constriction oblong deciduous cells, which seem to be spores of the second order. In *Ustilago receptaculorum* at least the secondary spores have a similar form, though not precisely the same origin, and these very rarely produce spores of the third order.

588. The Ustilagos are at once distinguished from *Uredo* and similar genera by their minute *dusty* spores which are void of any peduncle, or which are detached at a very early period of growth. *Thecaphora, Polycystis,* and *Tilletia,* which have somewhat similar habits, are all essentially distinguished by the structure of the spores. They are found in different parts of the plant; sometimes on the leaves and stems, as *U. longissima, hypodites,* and *typhoides,* but more frequently in the organs of fructification, which they deform at the same time that they appropriate all their nutriment. The leaves of Grasses affected by *U. longissima* have long narrow parallel bands filled with dusty spores, but *U. hypodites* destroys the whole stem with the inflorescense before it bursts through the sheath. We have seen Grass crops suffer materially from it, for where it once commences its attacks it is usually very abundant. *U. typhoides* in a similar way affects the stems of Reeds, making them totally unfit for thatching, for which they are the best and most durable material.

589. The smut again of the Indian Corn is by no means confined to the fruit. It frequently attacks the stem, and forms large swollen wen-like bodies many inches in diameter filled with spores, and the decomposed vessels of the plant. Maize is but little cultivated in Great Britain, but in some cases where the cultivation has been attempted the crop has not been free from this dreadful plague.

590. All our Cereals are more or less subject to be attacked, Wheat forming no exception, though smutty Wheat is comparatively

rare. Barley and Oats are subject to it, but seldom in such quantity as to attract notice. It was, however, peculiarly abundant during the present season, and in some cases destroyed at least one-third of the Barley crop. The crops were, however, so abundant that when a brisk wind had dispersed the spores the loss was scarcely felt. A notion of the abundance of the spores may be obtained from the fact that the ground where the smut was produced was of an uniform black all over. There was moreover a shower of black rain in the neighbourhood which was attributed to the smut; but as no competent person examined what fell, it is not quite certain with what the water was mixed.[19]

591. Though smut is highly destructive where it abounds, it is not so injurious to the harvested grain as bunt, because the spores are in great measure dispersed before the grain is ripe, which is not the case with bunt, the spores of which are frequently not set free till it is broken up by the flail or threshing machine, added to which it is entirely void of the disgusting fishlike odour which is so offensive in the bunt.

592. The question of most interest to the farmer is how he may get rid of the plague, for though he may speak of it as a good sign when there is but little of it, on the same principle which so often leads men to propitiate some unknown evil principle by good words, so long as the matter does not come home too closely to their experience, no one would pretend that it was good to have a third or more of the produce destroyed by it. The remedies are, undoubtedly, the same as those of which we shall have to speak under the article Bunt, but they are not so efficacious, because the seed is not so apt to be impregnated by the spores as bunted Wheat. The greater part is dispersed at an early period, and falls to the ground, where it is ready to attack the sprouting seed. We have, however, failed in obtaining smutty grain from seed purposely impregnated, which is scarcely ever the case with bunt. It is said sometimes to affect the stem as well as the inflorescence, but we have never seen any example.

593. We are not aware that any experiments have been made of the effect of smut spores taken as food. The *Ustilago* which affects the common Reed is said to produce severe headache where the Reeds are much infested.

594. *(Tilletia,* Bunt*).* The effect of bunt on corn is like that of

[19] There is no reason why there should not be showers of black rain from the mixture of smut as well as showers of yellow rain from that of the pollen of Pines, Oaks, or Sallows, a not very unfrequent occurrence.

smut, to convert the tissues into, or rather to replace them by, a mass of dust-like spores. In smut however these are soon dispersed; in bunt from the stronger texture of the walls they are in general retained and are not broken up till the flail is put to the harvest. In smut, though dirty and disagreeable, there is no offensive smell; in bunt the greasy spores have an odour like that of stale fish. There are moreover differences in point of structure. In smut the walls of the spores are simple, that is, not composed of cells, while in bunt they are reticulated with the dissepiments of the component tissue. The result of germination in the smut which affects Cereals is not ascertained so completely as that of many other parasites. In *Tilletia* they are very curious. Each spore protrudes a thread, from the tip of which grow other curved fusiform threads, which are ultimately connected by lateral processes.[20] When the connection is completed the threads produce globose spores, which sometimes produce others of a third order.

595. Though the germination of the spores is easily followed out the mode of entrance of their mycelium into the young Cereal has not yet been ascertained. That it does enter is certain, because corn rubbed with the spores of bunt will almost always give rise to bunted ears. The threads protruded immediately from the spores are larger than the stomates and cannot enter them, but the delicate threads which rise from them are quite capable of entering and may thus affect the corn.

596. Bunt is not confined to the grain, though that is its most usual situation. We have seen it in artificially inoculated Wheat, running in straight lines down the stem, like *Uredo longissima*. Wheat is oftener affected than any other plant, but bunt has been found on *Hordeum murinum*, *Agrostis Spica Venti*, and other Grasses. It is said also to be found on *Sorghum*, but *Tilletia Sorghi-vulgaris* is a very doubtful species, as the spores are quite different from those of *T. Caries*, and the mode of development agrees with that of those forms of the common smut which bear a hard rigid columella.[21]

597. No parasite is more injurious to Cereals than bunt, but happily it is one of the few affections of Plants which is readily controlled, insomuch that the proportion of bunted ears in a crop is a tolerably

[20] This was pointed out some years since in the Journal of the Horticultural Society of London.

[21] We have just received from India an excellent example of this condition in some cultivated Grass, the exact specific name of which we are unable to ascertain from the specimen.

sure indication of the degree of skill or care which belongs to the cultivator. Each farmer has his own remedy. Simple immersion in water alone is of considerable service from washing off the spores of the parasite, but if the crop is to be completely free, some addition must be made to destroy those which still adhere to the grain. Corrosive sublimate, arsenic, and blue vitriol are employed for this purpose, but besides the danger attendant on the use of such poisonous substances, the two former are apt to act upon the seed itself if from any delay consequent on bad weather, it is not sown at once. Blue vitriol, unless prepared of great strength, has not this bad quality. A very simple and effectual mode of treatment is to mix quicklime and boiling water together, and apply it hot to the Wheat placed in small convenient heaps, so that every seed may be covered with the mixture while still at a high temperature. This plan is called puddling. The most efficacious plan, however, though one which is little if at all practised in this country, is to make a strong solution of Glauber's salt (sulphate of soda). The Wheat is then steeped in the solution, and dried off with powdered quicklime, the effect of which is to decompose the sulphate of soda, the sulphuric acid combining with the lime to make sulphate of lime or gypsum, while the caustic soda is left behind to destroy the spores of the parasite.

598. It does not appear that Wheat much mixed with bunt is unwholesome. The colour of the bread made from it is injured, and the nutritive qualities probably impaired, but though extensively consumed at times by farmers and labourers we have never heard that it is injurious to health, nor is it as disagreeable to the taste as might be conceived from the nauseous smell of the raw fungus. Bunted Wheat is bought up principally by the gingerbread makers, for which purpose the dark colour is of no consequence. It might also enter safely into the composition of Katsup, the dark spores answering the same purpose as those of the Mushroom.

599. *(Uredines,* Rust*).* Under this are comprehended numerous parasitic fungi, which attack plants belonging to almost every natural order. Some of them are nearly harmless, while many are extremely mischievous. Their spores are of different colours, yellow, orange, white, brown, &c., and their structure very various.

600. The white rust is familiar to every one from its prevalence on Cabbages, Shepherd's Purse and various other Crucifers. The mycelium spreads amongst the tissue, distorting every part, and in the flowers increasing everything to an enormous size. A figure

illustrative of this will be found in the Transactions of the Horticultural Society of London, vol. 3, p. 266. The mycelium of parasitic fungi is often difficult to observe because of its minuteness, and the perplexity caused by the outlines of the cells of the matrix. In the white rust, *Cystopus,* it is so large that it is easily seen; and any one who is sceptical about the true nature of these plants cannot do better than to make it a subject of investigation. Nor is this the only point of interest. Few plants in point of fact are more curious as regards structure, and few were more puzzling till Tulasne explained that two kinds of spores are produced in the same heap, the one more numerous forming moniliform chains with cylindrico-globose articulations separated from each other by a short narrow connecting thread, the other larger, thicker, and darker, divided into three distinct lobes, after the fashion of *Triphragmium.* Both of these germinate, but the larger seem the more perfect. The same thing occurs in the common Rose Rust, which belongs to the genus *Coleosporium.* Some of its spores germinate at definite points, like many pollen grains. Roses often suffer greatly from this blight, which is capable of being propagated by the spores, as where the soil in which a healthy Rose tree is planted is sprinkled with water in which infected leaves have been immersed, the tree is pretty sure to be rusted the following season.

601. The most important, however, of the species of rust is that which attacks the spikes and leaves of corn. We must, however, first distinguish between *Uredo linearis* and *U. rubigo-vera,* the former being simply the young state of *Puccinia graminis* before the dissepiments are formed. As the two plants frequently grow together it was at one time thought that *U. rubigo-vera* was also a mere state of the Wheat mildew. As long as the rust is confined to the leaves it is of little consequence, especially if the growth of the plant be vigorous. The leaves at length flag, and the effect seems merely to check undue luxuriance; but if the spikelets and germen are affected, a circumstance which takes place at a later period of growth, the effects are disastrous. The matter which was intended to nourish the germen is diverted, while the mycelium causes a sort of hypertrophy, and the grain, which was at first swollen, becomes in consequence meagre, and shrivelled. In red Wheat the disease is scarcely ever prevalent, but in the white Wheats it is so virulent that in countries which do not suit them it is often almost impossible to secure seed. In all these cases so many of the spores fall to the ground that no system of washing or steeping is effectual.

The only remedy is to avoid growing those especial varieties which are most subject to the complaint, a remedy which is very easy where red Wheats form the staple of the crop, but where white Wheats are most suitable to the soil we fear that there is no known remedy. The rotation of crops is however greatly in favour of the cultivator, for rust is far less common on other cereals than on Wheat, though unhappily it occurs on many Grasses, by which the plague is propagated.

602. It is right to state that Desmazières considers the species which grows on the inflorescence as different from that which grows on the leaves, and has therefore published it as *U. glumarum* Roberge; but after an examination of his own specimens this opinion is not borne out, for there is no one essential character to separate them, nor are the spores as he describes them smooth, but minutely granulated as in undoubted *U. rubigo-vera.*

603. *(Gymnosporangium, Podisoma).* The very curious productions comprised under the genera which form the subject of our present notice cannot be considered as materially affecting the cultivator. They are, however, in themselves and the considerations they involve so important, that a treatise on the maladies of plants would not be complete unless it included a notice of them. They are confined exclusively to species of the genus *Juniperus,* on the branches of which they form clavate or lobed gelatinous masses which resemble externally the species of *Tremella,* which are so common on decaying sticks in winter. The branches, however, on which these genera grow are by no means decayed, and the same branch will produce a new crop for many successive years, each individual leaving behind every year a little orbicular disc, which waits merely for a new season to sprout out again into a fresh plant. In general the branches of the matrix are not at all distorted; but in *P. macropus* an orbicular excrescence is formed, looking very much like the strolilus of a Cypress.

604. This latter is very common in Pennsylvania upon those plants of the Virginian Juniper which have been closely clipped, and is known under the name of Cedar Apples, and brought into the market as a popular vermifuge. The trees, though covered with the parasite, do not seem to suffer, for as fast as the parasite grows so fast the swelling increases upon which it is developed. In like manner those species which affect the branches of other Junipers without causing much distortion, if injurious at all, are so only after a long series

of years, which is the more surprising as the large gelatinous masses must make a strong demand on the mother plant.

605. It was said that these parasites are externally like a *Tremella*. The resemblance is, indeed, not merely external, and there is no doubt that these plants form a nice connecting link between the two grand divisions *Coniomycetes* and *Hymenomycetes*. In *Tremella* the base of the plant consists of interwoven threads bearing at their tips large globose swellings which frequently divide into four lobes, each lobe giving rise to a long thread tipped by a boat-shaped spore. In like manner the base of the gelatinous mass in these parasites consists of a mass of flexuous distinct threads springing from a more intricate set beneath. The tip of each thread is crowned by a uniseptate somewhat conical cell which has all the appearance of the spore of a *Puccinia*. Each cell, however, germinates at two or four points, and the elongated threads resulting from this germination bear the true spores, which are broadly cymbiform and capable of germination. There is therefore a very close resemblance between the *Tremella* and the *Podisoma*. The great difference exists first in the arrest of development which takes place in the pseudospores of the latter, a circumstance which is still stronger in *Puccinia* and other allied genera; and secondly in the fact that the sporiform bodies in *Podisoma* germinate like true spores, while the apparent germination of the sporophores of *Tremella* is nothing more than an extension of the walls of the cell into filiform processes. In *Podisoma* the inner membrane protrudes in the form of a mycelium, exactly as the pollen tubes are protruded in Phaenogams. The better plan, perhaps, is to regard the growth of *Podisoma* and its allies as a sort of alternation of generations, the propagation of the plant depending upon the germination of the spores of the second or third order; and it is this postponement of propagation which in all probability keeps up the connection of the parasite with the parent plant. Months may elapse between the failure of the parasite and the appearance of a new crop; meanwhile the parasite has been making preparation for fresh attacks, for which had the ultimate germination taken place at once the nurse might not have been prepared for the reception of the new generation.

606. (*Puccinia*, Wheat Mildew, &c.). *Uredo* and the several genera which, with greater or less propriety, have been separated from it in consequence of a more intimate acquaintance with their structure and mode of development, are all distinguished by their uniseptate spores, whether produced singly or in the form of little necklaces upon the fertile threads. They vary considerably in colour, from an almost

pure white to yellow, purple and brown. The dark-coloured species, excluding the allies of *Ustilago,* which have been treated separately, tread very closely on the heels of *Puccinia,* and in some cases seem to be a younger stage of growth, or at least a secondary form of fruit analogous to the stylospores of *Sphaeriae,* unless indeed the *Pucciniae* which attend or follow them be conceived to be more secondary parasites, a notion which has some support in the fact that more than one species of true *Puccinia* sometimes grows in the same sorus. Making however as much allowance for this fact as it deserves, when it is considered that so many of the brown Uredines, as *U. Menthae, U. Vincae,* &c., have exactly analogous *Pucciniae,* as *P. Menthae, P. Vincae,* &c. which cannot be distinguished from them except after microscopical examination, and that the one seems to pass into the other, it requires strong evidence to convince an unprejudiced person that they are really distinct. *Uredo linearis,* which is at first yellow, may be traced with the greatest ease, passing into *Puccinia graminis,* so as not to leave the slightest doubt as to their identity.[22]

607. The genus *Puccinia,* then, is distinguished by the same habit as *Uredo,* the spores being produced in little cushion-like heaps beneath the cuticle of the plants on which they are parasitic. The spores are uniseptate, the upper division being for the most part broader than the lower; though in some species where they are elliptic they are equally divided. The surface is variously sculptured, and in some exotic species the outer coat shells off from the inner, as in a beautiful form which grows on *Amorpha,* in South Carolina. The spores arise from a distinct mycelium which creeps amongst the parenchym of the mother plant, exhausting its nutritive matter, and finally producing decay. These spores, however, are spores only of the first order, and do not immediately increase the plant. Whether they require impregnation for their further development is at present uncertain. Spermogonia have been found at present tolerably abundant in a few species only, as in *P. Anemones.* After a time, however, these primary spores or prothallus, if it be right to give them that name, germinate after the fashion of the spores of the higher Cryptogams. Each cell germinates; the upper from the apex, the lower from the commissure. The mycelium which proceeds from them, according to the observations of Tulasne, is rather coarse, septate or inarticulate, clavate in form, and producing a few short branches or processes, each of which has a single boat-shaped spore at its apex.

[22] Tulasne believes that almost all the *Uredines,* exclusive of *Ustilagines,* are mere stylospores of *Puccinia* and other allied genera.

These in their turn germinate, not from the protrusion of the inner membrane, as in the first case, but by extension of the outer, and give rise to a spore of the third order. The mode and time of introduction of the mycelium into the mother plant has not at present been observed, nor the stages of growth which precede the appearance of the sori upon the leaves or stem. It is not, however, probable that the spores adhere like those of Bunt to the grain, for they are not easily removed from their place, and if they did adhere they would be destroyed by the usual dressing in the same way as Bunt, which is not the case. In any case they do not germinate till spring. Wheat-mildew is one of the most formidable plagues against which the agriculturist has to contend, and unfortunately one against which he has no remedy. The very cultivation which is most conducive to a large produce in good seasons, is in unfavourable seasons productive of mildew. In bad mildew years the worst crops often suffer the least because they are less heavy. A pamphlet was addressed by the late Mr. Tycho Wing to the tenants of the Duke of Bedford at Thorney, calling upon them to clear out the ditches with which their fields are bordered, as the Reed constantly harboured a quantity of *Puccinia*, which he believed with good reason to be the same species with that of Wheat. The advice was undoubtedly good, but unfortunately the spores of *Puccinia* when once separated are capable of being blown about by every breeze. In fact, spores of such plants occur in the dust of the trade winds, as observed by Ehrenberg. If however they germinate while still attached, the spores of the second order are still more capable of being wafted everywhere. For the present, therefore, the farmer must be content to reckon mildew as one of the unfavourable circumstances which he must take into calculation in estimating the average annual value of land. In such case he at least will not be the sufferer.

608. *(Triphragmium, Phragmidium, Xenodochus).* As *Puccinia* differs from *Uromyces* in the accession of a dissepiment dividing the spore into two parts, which though never losing their adherence are nevertheless each of them capable of germination and of producing spores of the second order, so these genera severally differ from *Puccinia* in the accession of fresh dissepiments. In *Triphragmium* this usually takes place by the vertical division of the upper cell, but in a species from Texas, *T. deglubens*, sent to me by Mr. Curtis on some Leguminous plant, the second dissepiment is horizontal like the first, and from this *Phragmidium* differs merely in the greater number of dissepiments, and *Xenodochus* is the multiplication to such

an extent that the threads become curved and ultimately break. In all, the spores are accompanied by one-celled stylospores formerly referred to *Uredo,* and in *Triphragmium* and *Phragmidium,* spores of the second order are formed upon the germinating threads, which differ only from those of *Puccinia* in being globose instead of broadly cymbiform. The germination of *Xenodochus* has not yet been observed. In *Triphragmium* each cell has only a single pore for the emission of the mycelium, but in *Phragmidium* there are mostly three, and these lateral, even in the terminal joint.

609. *Triphragmium* was for a long time supposed to be confined to *Spiraea Ulmaria.* A beautiful form has lately been found by Tulasne on *Spiraea filipendula,* a second species occurs on *Isopyrum Thalictroides,* a third was found by Leveillé on *Meum athamanticum,* and I now figure [not reproduced] two additional species, *T. deglubens* and *clavellosum,* the latter of which grows apparently on some Cherry, and is remarkable for the forked processes with which it is sparingly clothed, and the rather long hyaline stem. Leveillé's species on *Meum* like this has spinulose processes, and like the former of them parallel dissepiments.

610. *Phragmidium* has at present occurred only on *Rosaceae.* The Raspberry Bramble, lesser Burnet, and Strawberry Potentilla produce well known species, but far the most interesting is *P. speciosum,* which occurs on Roses in America, and which were it once to assail our Rose gardens would be a most intolerable pest, as it attacks the twigs and forms such large and dense tufts that it would soon exhaust all their energy. The other species, though sometimes abundant, especially that upon the Bramble, can scarcely be said to be formidable pests. The spores, as far as is known, do not germinate till the spring of the following year, when the tender leaves of their matrix are ready to receive the infant mycelium, a fact equivalent to that which Fries has observed in the *Rhytisma* of the Maple.

611. *Xenodochus* has hitherto been found only on the greater Burnet, and is especially interesting, because it seems the highest stage at which a *Puccinia* can arrive without the addition of the gelatinous element which makes *Podisoma* so conspicuous and so different to the outward eye from all allied parasites, and secondly because it connects these true parasites so clearly with such false parasites as *Torula.*

612. With this genus our remarks on the Uredinoid parasites will close, which though once despised and advisedly considered worthy of neglect as incapable of definition, and mere metamorphoses of

the cellular tissue of plants, are now by the researches of Tulasne and others proved to be amongst the most interesting of fungi, and as clearly productions perfectly distinct from the matrix, and subject to their own especial laws, as the highest Agaric or Batarrea. The knowledge, too, that the germination of the spores of many species, especially those in which they remain firmly attached to the matrix, does not occur till some months after their production, is calculated to throw great light on the mode of their development on the especial plants which they attack. This we trust will not long remain a mystery, and the circumstance of a prize for this especial object having been proposed by the French Academy, leads us to hope that the same tact and perseverance which has unravelled so many mycological knots will be rewarded with the development of this also.

613. *(Glœosporium, Septoria, Phyllosticta, Pestalozzia, Vermicularia).* These genera may be quoted as examples of the remaining fungi of the natural order to which the rusts and other allied pests belong, as destructive to plants, and truly parasitic. Some of them have proved formidable evils to the cultivator; while others, though injurious in a lesser degree, are so unimportant as not to attract his notice. It is true that many of the genera are not what botanists call autonomous, that is complete and independent in themselves, but on the contrary are mere conditions of species which in their perfect form assume very different characters; but this is a point which affects the botanist or systematist only and has nothing to do with the question whether they are such noxious plants as the cultivator must if possible guard against.

614. *Glœosporium concentricum* (*Cylindrospora concentrica* Greville) than which few plants have been less understood, is sometimes the plague of Cauliflower growers in spring. I have seen large beds wearing the most unhealthy aspect and materially injured in produce, by myriads of these parasites attacking every leaf. The structure is most simple. There is merely a very obscure mycelium studded with almost obsolete sporophores, each of which bears a little sub-cylindrical spore. The spores are so numerous that when the cuticle with which they are covered contracts on the mass from deficiency of moisture in the leaf, or from any other cause, the spores ooze out in the form of a gelatinous globule or irregular thread. *Glœosporium fructigenum* Berk., in *Gardeners' Chronicle,* 1856, p. 245, forms brown spots on Apples, which it soon reduces to decay by means of its abundant mycelium. There are many other species differing slightly in the form of the spores, but agreeing in general character.

615. *Septoria* is a genus which abounds in species, the greater part of which are probably a mere secondary form of other fungi. Some of them however are very destructive. Amongst them is one which affects Peas in damp weather, attacking the pods before they come to perfection, and preventing the development of the seeds, but sometimes invading the flowers themselves as soon as they are expanded. This is particularly destructive in Scotland, but I have seen whole crops materially injured by it in England. Another infests the knots of Wheat stalks just as the seed is swelling. In a short time the knot perishes and as no more nutriment can be conveyed to the plant, the produce is thin and shrivelled, like that of Wheat affected by mildew. Another affects Grapes after they are perfectly formed, just before they ripen, and causes speedy putrescence. In these fungi there is an obscure perithecium. The spores are for the most part cylindrical, and in the more typical species repeatedly septate. *Septoria rufomaculans* Berk. in *Gard. Chron.*, 1854, p. 676, for instance, the species which attacks Grapes, agrees with the *Glœosporium* of the Apple just mentioned, not only in its effects, but in its sub-cylindrical spores, but in this case there is a perithecium, while in the other the spores were simply covered by the discoloured cuticle.

616. *Phyllosticta* forms brown specks upon the leaves of a variety of plants, and has large uniseptate spores, mostly of an irregular form, as in . . . *Phyllosticta Fragariae*. Most of the species are innocent enough, or if destructive they are confined to weeds, whose maladies attract no notice. But the Strawberry Phyllosticta is sometimes most injurious, as in cases noticed in the *Gardeners' Chronicle,* 1856, p. 616, the coarse mycelium soon converting the tissues into a putrescent mass.

617. *Pestalozzia* is remarkable for the great beauty of its spores, which are surmounted by a delicate crest. The species appear to belong principally to warm climates. I have several from the warmer United States, and a very fine form from the heart of India near Secunderabad. A short time since however, the Camellias and Coniferae in one of our leading nurseries were suffering from one of the species, a circumstance which surprised me as I had seen no native specimens before. I asked in consequence whether the Camellias were not imported, and this proved to be the case, and from the importation with them of this little parasite a loss of some hundreds of pounds was soon sustained. It is difficult therefore to say that any of these obscure particles may not eventually prove a serious scourge.

618. *Vermicularia* might seem at first sight not to be a true parasite;

I have seen it however so destructive to a bed of White Nocera Onions, while yet in a growing state, that it certainly requires notice here. There is some reason to believe that the peculiar species which affects this Onion was imported with the seed, as it was confined to one variety and occurred in more than one locality on plants raised from the same packet of seed,[23] a circumstance which is not without its parallel in the annals of horticulture.

619. The main question is how are such evils to be remedied. Unfortunately no favourable answer to this question can at present be given. The evil is in general not discovered till it is too late to apply a remedy, even were one known. The outward influences however which favour their growth are at present in great measure unknown, and since they attack plants no less in uncultivated spots than in the artificial soil of our gardens, we cannot ascribe their presence entirely to high manuring or to other conditions attendant on cultivation.

620. *(Polyporus, Dædalea, &c.).* I have hitherto considered those Fungi only which are true parasites and live at the expense of the living tissues of the matrix, exhausting their vitality and ultimately inducing death. There are however a great many Fungi which, though they affect living vegetables, and are present in their tissues as minute mycelium during health, prey upon these structures only when old age, disease, or accident has already reduced their powers of resistance or brought on partial decomposition. The presence of mycelium in the cells of apparently healthy plants has been shown by Reissek and others, and I believe that Mr. Quekett has lately made a valuable series of observations on the same subject, though I have no information on the matter, except from verbal report. Certain it is that mycelium is deposited in considerable quantities in decayed structures surrounded on every side by healthy tissue, through which the spores or minute spawn must necessarily have penetrated, except such phenomena are to be explained by spontaneous generation, a doctrine which is losing ground every day, even in the minds of the most speculative of our continental neighbours.

621. It is quite obvious that all organic structures must have a limited existence. Life may be carried on for a hundred years or more in individual cells or in an aggregation of such individuals; new layers may be deposited year after year within the cells till the cavity is all but obliterated, but after a time the cell walls will become incapable of performing their functions, vitality is in consequence impaired

[23] See *Gard. Chron.*, 1851, p. 646, compared with p. 595.

or ceases altogether, and the mycelium which was already present attacks the walls and rapidly increases: neighbouring tissues become tainted by the putrefactive ferment, the affected tissue obtains communication with the external air, and the perfect Fungus is at length developed. No sooner has this process been completed than the mycelium spreads still more rapidly by favour of external circumstances, and in a few years the whole tree perishes. This is a process which may be traced from time to time in the case of such Fungi as *Polyporus hispidus* and *Polyporus squamosus*, and if the Fungus has once gained possession of the upper part of a tree, the evil is generally so widely diffused that the case does not admit of remedy. If the upper part of an Apple tree, for instance, be attacked by *Polyporus hispidus*, as is frequently the case, attempts may be made by heading down to induce a new growth. But in the majority of instances the process will be found useless. New shoots may at first be made, but in a few years the general vitality will be reduced so low that the shoots will not be properly nourished and the tree will fail. This is not indeed equally the case with every species of Fungus. Plum trees, for example, which have been attacked by *Polyporus igniarius*, will make a healthy growth and produce fruit for some years. After a time however the new branches will inevitably suffer like the old.

622. Internal decay attended by mycelium is not however always consequent upon mere decrepitude. In some cases undoubtedly the spores or spawn of Fungi are more readily admitted to the interior from below, or decay accompanied by such rudiments of Fungi may extend in the same direction. In the Larch rot the disease undoubtedly appears first in the main roots, from which decay extends upwards till the centre of the trunk is hollow without any serious external symptoms, inasmuch as the outer layers of tissue are still healthy. These however are at last involved, and the tree assumes a sickly aspect and dies. In other cases where trees are grown from old stocks, which are always more or less decayed, the seeds of disease are often imbibed from the first moment of growth. Such trees never produce sound timber, and in the case of Oaks may usually be known by the foxy tint of the heart wood. In other respects the wood may be apparently sound, but if it is employed in building, or in any other way where circumstances may favour the development of the latent mycelium, *Dædalea quercina* will soon make its appearance and induce rapid decay.

623. These are, however, far from being the only species which though not true parasites accelerate decay where it has once com-

menced. *Agaricus* [*Pleurotus*] *ostreatus, A.* [*P.*]*ulmarius,* and many other species have similar habits, as have a host of Polypori, besides those mentioned above. Where the evil has once commenced, and it is desirable if possible to save the affected tree, the only remedy is to cut out freely the part where the fungus has appeared, to wash the cavity with a solution of corrosive sublimate or some other substance destructive to the mycelium of Fungi, and then to prevent all access of the external air by some impervious composition.

Remedial measures

A. CERTAIN

668. *Rational. If we compare vegetable with animal pathology, as regards remedial measures, we shall find a great resemblance in the history of the treatment of disease, making due allowance for the superior attention which has been paid to the latter branch of science. A few remedies only have in the first instance been immediately derived from a perfect knowledge of the origin and nature of particular maladies. The greater part are either strictly empirical, or such as have at length been proved to be consistent with chemical laws in their connection with pathology, though derived originally from mere fortuitous trials, whose good results have been confirmed by frequent repetition, and so have become matters of experience. The doctrine of signatures, for example, may first have pointed out the common Blackberry as useful in attacks of red gravel, while chemistry shows that it contains citrate of potash, an approved remedy in the malady upon strictly scientific grounds. Abundant instances of a similar description might easily be quoted.

669. Remedies may be divided into two classes, those which are certain and those which are uncertain. The Pharmacopeia contains a large quantity of remedies which are very uncertain in their results, and the same may be said of many practices which are current amongst gardeners to remedy or palliate disease. Several of the remedies, on the other hand, which are applied in vegetable pathology, though successful, rest upon no rational principle. A whole class of remedies, however, is not only certain in their results or nearly so, except where disease has reached too great a height, but altogether rational in principle. Plants cannot flourish without proper food, due ventilation, a temperature suited to their peculiar nature, access to light, and other climatic influences. Where they suffer

from a derangement or want of proper modification of any of these particulars, and the causes of disease are known, the rational remedy is to restore the requisite conditions, and the effect will be all but certain. A great part of the cultivator's skill and knowledge must necessarily be directed to such points. Again, though moisture is absolutely necessary to the ordinary routine of vegetation, excessive moisture is sure to lead to evil, and if the roots are constantly steeped in stagnant and perhaps noxious water, while the temperature is depressed by the same cause, a dropsical or chlorotic condition will ensue, which can only be remedied by the removal of the cause of evil. When proper drainage is secured, the evil will in the majority of cases cease. Suppose, again, that it is ascertained that fungal threads in contact with the healthy but tender cells of the spongelets or young roots will induce disease, and that pieces of root left in the soil, or smaller fragments of vegetable matter which have not undergone thorough decomposition, send off mycelium which at length comes in contact with these spongelets. The careful cultivator will take pains to prevent the evil, by the removal of all such matters, or the exclusion of it from his composts. This will not indeed cure disease when it has once arisen, but it will tend to prevent it.

670. **Empirical. Some certain remedies have arisen however from the trial of various bodies without any rational hope of a good result. It is uncertain for instance what first induced the use of mineral poisons against Bunt, one of the most formidable diseases of the farm. They were certainly applied long before the true nature of the malady was even suspected, much more before anything was known of the growth of such fungi. Their effect is all but certain when properly employed, and improvements have been made since the disease was better understood, and the laws of chemistry ascertained. Bunt is now understood beyond all doubt to arise from the attack of a parasitic fungus, and the effect of mineral poisons on such fungi is also matter of experience. The remedy therefore, though in the first instance empirical, is now perfectly rational. The same may be said of the use of sublimed sulphur against white mildew. Sulphur was used constantly as a remedy against this complaint in hothouses, before the nature of the disease was known, and it is found to be applicable to the same purpose in various stages. It is now matter of certainty that sulphurous acid accompanying it, or formed by decomposition, together with sulphuretted hydrogen, acts fatally upon the threads of the mould; and the remedy though at first empirical is now strictly rational. The experience acquired from

such cases may lead to useful results in others, and thus remedies at present doubtful may rest upon rational grounds.

B. DOUBTFUL

671. *Rational. The ultimate result of experiment is for the most part more or less uncertain. If, however, it rests upon rational grounds, and springs from knowledge, it is at the least hopeful. Sulphur is, for instance, an approved remedy in the case of white mildew, where the mycelium is for the most part exposed to its action. Where the mycelium, as in the Potato, runs amongst the tissues, it is difficult to bring it in contact with it. The proposition, therefore, to apply sulphur to the cut tubers when planted rests upon rational grounds, whether it may lead to any good result or not. Experience, again, has shown that the application of the same remedies which are effectual against bunt does not succeed against smut or mildew. In bunt the spores go to the barn with the seed, and the poison is at once applied; in the other cases they are either altogether dispersed, or though carried home upon the straw of such a nature as not to adhere readily to the grain.[24] If then a rational remedy is to be adopted it must be something which will act upon the spores in the field, and not upon the grain. All other attempts will be sure to fail. Plants, again, from original constitutional weakness or from temporary causes acquire a yellow unhealthy hue, and if left to themselves will not recover. The causes of such a chlorotic condition may not be strictly the same with those which produce an analogous condition in man. It is, however, scarcely irrational, in the absence of correct means of comparison, to apply the remedy which in animal pathology is often attended with such favourable results, and to use salts of iron against vegetable as well as animal Chlorosis. The result of such treatment is still uncertain, but the treatment cannot fairly be charged with folly.

672. **Empirical. A large class of supposed remedies rests however upon no rational grounds whatever. When the cholera was first prevalent almost every conceivable substance was tried in the vain hope of hitting upon some specific remedy. Almost the only success however which has been obtained in the treatment of this formidable disease, has been achieved from a study of its nature and symptoms. As might have been expected all other efforts have been useless. Blight compositions are for the most part doubtful in their

[24] It may be objected that a few late ears infested with smut, which have not burst through the sheath, may be carried home with the crop. We know that this is sometimes the case, but it is not so common as to be of material consequence in the question.

results, because they profess to treat diseases of a very different nature by the same remedy. Such remedies are necessarily empirical, and even where the expense is not an object may lead to results worse than the original disease. The mere loss of money in the first instance may be a minor consideration; still where the effect is not absolutely certain, and where the treatment has been purely empirical, some rational grounds may exisit for occasional success. Salt is often for instance used as a remedy against Onion mildew. There is no certainty that the salt which promotes the growth of the Onion may not also promote the growth of the mould upon which the disease depends, but at the same time the increased vigour of the plant due to the use of salt may render it more able to resist the attacks of the parasite. So, again, in the disease called clubbing, the use of wood-ashes is empirical and uncertain, and yet from the excess of nitrogenous matter in the diseased roots, it is very possible that the potash may be useful in repressing some chemical tendency to store up nitrogen.

[*Concluding Remarks*]

We have now arrived at the conclusion of more than three years of continued labour, in a field which has been little cultivated. The result is decidedly favourable to increased study of vegetable disease, and to a high estimation of the importance of the subject. The series might have easily been carried to a much greater length, and a few subjects have been omitted or overlooked, which if the series should be published in a collected form, must be inserted in their proper place. It is, however, time to come to a conclusion, lest the constant recurrence of the same familiar heading, like the too frequent intrusion of a friend, should prove wearisome. Still, though the series is finished, we shall be grateful to those correspondents who will communicate new forms of disease, or important information on those already recorded, and we can assure them that their own increased attention to morbid appearances will be rewarded by many an improvement in their means of sustaining perfect health in the objects which they cultivate.